DIVISION OF BIOLOGICAL SCIENCES

The Division of Biological Sciences provides a unified curriculum for undergraduate majors enrolled in either the College of Agriculture and Life Sciences or the College of Arts and Sciences. Courses in biological sciences are integral to many disciplines and are basic requirements in many schools and colleges at Cornell.

Graduate study in the biological sciences is administered by more than a dozen specialized fields within the Graduate School, as described in the Announcement of the Graduate School.

ORGANIZATION

The Division of Biological Sciences is composed of seven sections: Biochemistry, Molecular and Cell Biology; Ecology and Systematics; Genetics and Development; Microbiology; Neurobiology and Behavior; Physiology; Plant Biology; and, in addition, the L. H. Bailey Hortorium and the Shoals Marine Laboratory.

Student services are provided by the division's Office for Academic Affairs and the Behrman Biology Center, both located in Stimson Hall, where academic advice, information on biological sciences course offerings, other important information, and counseling are available for undergraduates. The Office for Academic Affairs also follows the progress of biology majors and works closely with faculty advisers. Additional services and resources of the Biology Center include academic program planning, tutoring, lecture tapes, examination files, and information on undergraduate research opportunities. The center has comfortable areas for studying and relaxing.

The Shoals Marine Laboratory, a cooperative venture with the University of New Hampshire, is located on Appledore Island in the Gulf of Maine. Its base office in Stimson Hall provides advising and career counseling for students interested in the marine sciences and administers the SEA Semester program for Cornell students pursuing studies at Woods Hole or aboard the schooner *Westward* or brigantine *Corwith Cramer*.

FACULTY

P. J. Bruns, director; H. T. Stinson, Jr., associate director; E. Adkins-Regan, K. K. Adler, E. E. Alani, C. F. Aquadro, W. J. Arion, A. H. Bass, D. M. Bates, A. Bensadoun, K. W. Beyenbach, A. W. Blackler, S. E. Bloom, R. Booker, A. C. Borror, A. P. Bretscher, W. J. Brown, J. M. Calvo, R. R. Capranica, B. F. Chabot, J. L. Cisne, R. A. Corradino, W. L. Crepet, P. J. Davies, J. I. Davis, T. E. Dawson, A. A. Dhondt, J. J. Doyle, S. E. Ealick, T. Eisner, S. T. Emlen, P. P. Feeny, G. W. Feigenson, J. W. Fitzpatrick, A. S. Flecker, R. H. Foote, J. E. Fortune, T. D. Fox, M. A. Geber, W. C. Ghiorse, J. Gibson, Q. H. Gibson, R. F. Gilmour, M. L. Goldberg, C. H. Greene, N. G. Hairston, Jr., B. P. Halpern, M. R. Hanson, R. G. Harrison, R. M. Harris-Warrick, C. D. Harvell, L. O. Hedin, J. D. Helmann, L. A. Heppel, G. P. Hess, P. C. Hinkle, C. D. Hopkins, K. A. Houpt, T. R. Houpt, R. W. Howarth, S. H. Howell, H. C. Howland, R. R. Hoy, T. C. Huffaker, A. T. Jagendorf, L. W. Jelinski, P. A. Karplus, M. N. Kazarinoff, E. B. Keller, K. J. Kemphues, K. A. R. Kennedy, L. V. Kochian, A. S. Kondrashov, T. A. LaRue, R. L. Last, A. C. Leopold, S. A. Levin, J. K. Liebherr, G. E. Likens, J. T. Lis, E. R. Loew, M. A. Luckow, D. McCobb, A. R. McCune, J. M. Fessenden MacDonald, R. J. MacIntyre, E. L. Madsen, P. L. Marks, R. P. Mortlock, J. B. Nasrallah, M. E. Nasrallah, P. W. Nathanielsz, L. Nicholson, K. J. Niklas, K. C. Nixon, T. G. Owens, D. J. Paolillo, M. V. Parthasarathy, D. Pimentel, T. R. Podleski, A. G. Power, W. B. Provine, A. Quaroni, H. K. Reeve, M. E. Richmond, J. W. Roberts, D. Robertshaw, E. Rodriquez, R. B. Root, M. J. Rossman, J. B. Russell, M. M. Salpeter, A. M. Schneiderman, T. D. Seeley, D. I. Shalloway, J. P. Shapleigh, P. W. Sherman, R. M. Spanswick, D. B. Stern, V. J. Stewart, D. N. Tapper, J. F. Thompson, R. Turgeon, B.-K. Tye, S. Via, V. M. Vogt, C. Walcott, R. H. Wasserman, R. O. Wayne, W. W. Webb, N. F. Weeden, Q. D. Wheeler, D. B. Wilson, S. C. Winans, D. W. Winkler, M. F. Wolfner, J. F. Wootton, R. Wu, S. A. Zahler, S. H. Zinder

Other Teaching Personnel

G. S. Albrecht, J. E. Blankenship, R. A. Calvo, P. W. Concannon, M. L. Cordts, C. Eberhard, P. R. Ecklund, J. C. Glase, J. B. Heiser, B. R. Johnson, C. H. McFadden, S. Merkel, H. T. Nivison, C. M. Rehkugler, H. C. Reiss, B. Sneath, B. M. Tyler

DISTRIBUTION REQUIREMENT

In the College of Agriculture and Life Sciences, the biological sciences distribution requirement (Group B) is for a minimum of 9 credits, including at least 6 credits of introductory biology satisfied by Biological Sciences 109–110, 105–106, or 101 and 103 plus 102 and 104, or 107–108 or any combination of the first term of one sequence and the second term of another. Advanced placement in biology with a score of 4 or 5 (6 or 8 credits, respectively) satisfies the requirement for introductory biology. The additional credits may be satisfied by any biological sciences courses *except Biological Sciences 152, 200* (unless permission of associate director is obtained), *208, 209, or 367.*

For College of Arts and Sciences students matriculating before fall 1992, the biological sciences distribution requirement is for a two-semester introductory biology sequence selected from Biological Sciences 109–110, 105–106, or 101 and 103 plus 102 and 104, or 107–108 or any combination of the first term of one sequence and the second term of another. An Advanced Placement score of 4 or 5 fulfills one-half the distribution requirement. Students must take an upper-level biology course to complete the distribution requirement in biological sciences. The remainder of the distribution requirement may be satisfied by an upper-level course (200+) offered by the Division of Biological Sciences *other than Biological Sciences 152, 200* (except by permission of associate director), *208, 209, or 367*; Anthropology 101; or Chemistry 222 or any combination of the first term of one sequence and the second term of another.

For students in the College of Arts and Sciences who matriculate fall 1992 or later, all courses offered by the Division of Biological Sciences can be used toward fulfillment of the biological distribution requirement except *Biological Sciences 152, 200* (unless permission of the associate director is obtained), *208, 209, or 367.* The following courses are especially suitable for the distribution requirement because they have no prerequisites: Biological Sciences 101–104, 105–106, 107–108, 109–110, 154, 160, 170, 184, 192, 207, 212, 246, 264, 266, 275. *Note that introductory biology can only count for distribution credit when taken as a two-semester sequence: 109–110, 105–106, or 101 and 103 plus 102 and 104, or 107–108, or a combination of the first term of one sequence and the second term of another.* Advanced placement in biology with a score of 4 or 5 (6 or 8 credits, respectively) may be applied to the Group 1 distribution area in accordance with regulations stipulated by the Arts College.

In the College of Human Ecology, the natural sciences distribution requirement is for at least 6 credits selected from Biological Sciences 109–110, 101 and 103 plus 102 and 104, 105–106 or 107–108 or from specified courses in chemistry or physics. Advanced placement in biology with a score of 4 or 5 (6 or 8 credits, respectively) also satisfies the distribution requirement in the natural sciences.

Note: Biological Sciences 101–102–103–104 should be taken as a unit by students of any college except those with advanced placement credit.

Switching from one introductory biology sequence to another at midyear may not be possible because of variation in presentation of topics. Students must receive permission of the instructor to switch sequences. Taking sequences in reverse or inconsecutive order is strongly discouraged.

THE MAJOR

The Division of Biological Sciences offers a major in biological sciences to students enrolled in either the College of Agriculture and Life Sciences or the College of Arts and Sciences. The undergraduate program is

coordinated for students in both colleges through the division's Office for Academic Affairs, where students submit their applications to the major and obtain biology faculty advisers.

During the second semester of the sophomore year, all students who intend to major in biological sciences must apply for acceptance into the major with the associate director for academic affairs, in 200 Stimson Hall. Students in the College of Agriculture and Life Sciences who were admitted directly to the major complete the application process to declare a program of study area and to assure satisfactory progress toward completion of the major. Acceptance into the major requires completion of the course sequences in introductory biology, chemistry, and mathematics (see requirements 1–3 below), plus one semester of organic chemistry lectures. In addition, a 2.75 Cornell cumulative grade-point average is required for final acceptance into the major except for those students admitted directly to the major as freshmen (College of Agriculture and Life Sciences students only) or as transfers. Students in the process of completing these prerequisites for admission to the major may be accepted on a *provisional* basis. Final acceptance into the major is required for graduation with a biological sciences major. It is the student's responsibility to assure that final acceptance has been granted.

Whenever possible, students should include the introductory biology, chemistry, and mathematics sequences in their freshman schedule and complete the organic chemistry lecture course in their sophomore year. Students are not encouraged to continue with the major in biological sciences unless performance in these four subjects gives evidence of capacity to perform satisfactorily at a more advanced level.

The requirements for the biological sciences major are listed below. These courses, with the exception of the language requirement, should be taken for a letter grade, unless the course is offered for S-U grades only.

1) **Introductory biology for majors** (one year): Biological Sciences 101 and 103 plus 102 and 104, or 105–106. Biological Sciences 107–108, offered during the eight-week Cornell Summer Session for 8 credits, also satisfies the introductory biology requirement for majors. Students may choose to accept advanced placement if they have received a score of 5 on the Advanced Placement Examination of the College Entrance Examination Board (CEEB). Students with a score of 4 must fulfill the introductory biology requirement by taking Biological Sciences 101–102, 101 and 103, 102 and 104, or 103–104. These students should consult information available in the course office (1140 Comstock Hall) and in the Biology Center (216 Stimson Hall) to determine which semester to take to complete the introductory biology requirement. For students in doubt, completion of Biological Sciences 101 and 103 is advised. These students receive a total of 8 introductory biology credits (4 AP credits plus 4 course credits).

2) **General chemistry** (one year): Chemistry 207–208,* or 103–208, or 215–216.*

3) **College mathematics** (one year): two semesters of calculus (Mathematics 111–112, 191–192, or their equivalents) or one semester of calculus (Mathematics 106, 111, 191, or equivalent) plus either Mathematics 105 or Statistics and Biometry 101. Education 115 may not be used to fulfill any part of this requirement.

4) **Organic chemistry**: Chemistry 253 and 251, or 253 and 301, or 257 and 251, or 357–358 and 251, or 357–358 and 301, or 359–360 and 251, or 359–360 and 301.

5) **Physics:** Physics 207–208,* 112–213,* or 101–102. Those who take Physics 112–213 are advised to complete Physics 214 as well.

6) **Genetics:** Biological Sciences 281.

7) **Biochemistry:** Biological Sciences 330, or 331 and 332, or 333.

8) **Evolutionary Biology:** Biological Sciences 278.

9) **A program of study** selected from the outline below.

10) **Foreign language:** students registered in the College of Agriculture and Life Sciences must satisfy the foreign language requirement of the Division of Biological Sciences by (a) presenting evidence of successful completion of three or more years of study of a foreign language in high school or (b) attaining a score of 560 or more on the reading portion of the College Entrance Examination Board achievement test or (c) achieving "qualification" status in a language as defined by the College of Arts and Sciences or (d) successfully completing at least 6 college credits in a foreign language. Students registered in the College of Arts and Sciences must satisfy the language requirement as stated by that college.

*Since modern biology has an important physical and quantitative orientation, students are advised to undertake basic science courses that emphasize this approach. Asterisks in the above list indicate the courses that provide this orientation, but all courses listed are acceptable.

Although not required for the biological sciences major, a course in statistics is recommended for students planning graduate study or a research career. Students should consult their faculty advisers when choosing appropriate courses in statistics.

Programs of Study and Requirements

As noted in the list of requirements above, students accepted into the biological sciences major must choose a program of study. The program of study requirements are designed to help students achieve depth in one area of biology while ensuring that the selected advanced courses form a coherent and meaningful unit. Because of the flexibility allowed in satisfying these requirements, students should consult their faculty advisers. The possible programs of study are listed below.

1) *Animal Physiology:* BIOAP 311, Introductory Animal Physiology, Lectures; BIOAP 313, Histology: The Biology of the Tissues; BIOAP 316, Cellular Physiology; and BIOAP 319, Animal Physiology Experimentation. The Program of Study in Animal Physiology emphasizes whole-animal, tissue, and cell physiology, and provides considerable opportunity for studies using live animals. It is intended especially for students contemplating careers in biomedical practice or research.

2) *Biochemistry:* Quantitative Chemistry (Chemistry 300 or completion of Chemistry 215–216 for the general chemistry requirement for the major); a minimum of four credits of organic chemistry laboratory (Chemistry 301–302 or 251–252–302 or 301 or 251–252); one of the 5-credit options of Biochemistry (331 and 332 or 330 and 334) is strongly recommended; 4 credits of biochemistry laboratory courses (BIOBM 630) (see note below); and Physical Chemistry (Chemistry 389–390 or 287–288 or 287–390 or 389–288). Note that Chemistry 288 is designed for biologists. It is recommended that students interested in graduate work in biochemistry take the more rigorous organic chemistry and physics sequences (Chemistry 357–358 or 359–360 and Physics 207–208), six credits of organic chemistry laboratory, and a third semester of calculus in preparation for the more rigorous physical chemistry sequence (Chemistry 389–390). Students interested in biochemistry should complete a year of introductory chemistry other than Chemistry 103–104 before the start of their sophomore year. Students are also urged to complete introductory biology in their freshman year.

   Note: Formerly the 600-level biochemistry laboratory courses were taught separately as BIOBM 630, 634, and 638. These courses have been reorganized as sections under a single course number. The specific courses offered in any semester may vary. All courses emphasize qualitative and quantitative aspects of modern approaches to research in biochemistry, molecular and cell biology, and expect some student input into experimental design based on readings of original papers.

3) *Cell Biology:* Chemistry 300 or 215–216, Quantitative Chemistry; BIOBM 432, Survey of Cell Biology; 4 credits of biochemistry laboratory courses (strongly recommended to include the Experimental Cell Biology section of BIOBM 630) (see "Note" under Biochemistry); and at least 5 additional credits chosen from the following courses: BIONB 222, Neurobiology and Behavior II: Introduction to Neurobiology; BIO G 305, Basic Immunology; BIOAP 313, Histology: The Biology of the Tissues; BIOPL 345, Plant Anatomy; BIONB 425, Natural History of Ion Channels; BIOBM 435–436, Undergraduate Biochemistry Seminar; BIOBM 437, Oncogenes and Cancer Viruses; BIOPL

444, Plant Cell Biology; BIO G 450, Light and Video Microscopy for Biologists; BIOGD 483, Molecular Aspects of Development; BIOBM 632, Membranes and Bioenergetics; BIOBM 636, Cell Biology; BIOBM 639, The Nucleus.

Students interested in cell biology should complete a year of introductory chemistry other than Chemistry 103–104 before the start of their sophomore year. Students are also urged to complete introductory biology in their freshman year and are strongly encouraged to take one of the 5-credit options of Biochemistry (331 and 332 or 330 and 334). If graduate work in cell biology is anticipated, students should consider taking a physical chemistry sequence (Chemistry 389–390 or 287–288 or 287–390 or 389–288).

4) *Ecology and Evolutionary Biology:* BIOES 261, Ecology and the Environment, and 10 credits from the following course lists, including at least one course from each group:

(a) BIOPL 241, Introductory Botany; BIOES 274, Functional and Comparative Morphology of Vertebrates; BIOES 373, Biology of the Marine Invertebrates; BIOES 466 and 468, Physiological Plant Ecology, Lectures and Laboratory; BIOES 471, Mammalogy; BIOES 472, Herpetology; BIOES 475, Ornithology; BIOES 476, Biology of Fishes; ENTOM 212, Insect Biology.

(b) BIOES 263, Field Ecology; BIOES 272, Functional Ecology of the Vertebrates; BIOPL 448, Plant Evolution and the Fossil Record; BIOES 452, Herbivores and Plants: Chemical Ecology and Coevolution; BIOES 455, Insect Ecology; BIOES 456, Stream Ecology; BIOES 457 and 459, Limnology: Ecology of Lakes, Lectures and Laboratory; BIOES 461, Population and Evolutionary Ecology; BIOES 462, Marine Ecology; BIOES 463 and 465, Plant Ecology and Population Biology, Lectures and Laboratory; BIOES 464, Macroevolution; BIOES 470, Ecological Genetics; BIOES 473, Ecology of Agricultural Systems; BIOES 478, Ecosystem Biology; BIOES 479, Paleobiology; BIOGD 481, Population Genetics.

Note: One 400-level, 4-credit course (including 4 credits from BIOSM 364) offered at Shoals Marine Laboratory may be applied toward the 10 credits. Students are encouraged to gain experience in some aspect of field biology through course work at a biological field station or work experience.

Note: The Ecology and Evolutionary Biology program of study offers an undergraduate specialization in Marine Biology and Oceanography. A description of this specialization can be found in the section entitled COURSES IN MARINE SCIENCE.

5) *General Biology:* The Program of Study in General Biology requires a minimum of 13 credit hours from courses offered by the Division of Biological Sciences in addition to courses counted towards requirements 1–8 above. These credits must include one course (200-level or above) from the courses fulfilling requirements for at least three of the eight other programs of study (see pages 128–129), and must include a course with a laboratory (200-level or above) and a minimum of two upper-level (300 and above) courses of two or more credits. BIOPL 341 may not count as the lab course. BIO G 498 may not be used to fulfill the requirements of this program of study. BIO G 499 (minimum of 2 credits, but no more than 3 credits) may count as one of the upper-level courses, and may count as the laboratory course with approval of the adviser, but it cannot count as a course representing a program of study.

6) *Genetics and Development:* A minimum of 13 credits, usually chosen from the following courses: BIOGD 385, Developmental Biology; BIOGD 389, Embryology; BIOGD 480, Seminar in Developmental Biology; BIOGD 481, Population Genetics; BIOGD 482, Human Genetics and Society; BIOGD 483, Molecular Aspects of Development; BIOGD 484, Molecular Evolution; BIOGD 486, Advanced Eukaryotic Genetics; BIOGD 488, Molecular Genetic Analysis (up to 3 credits); BIOBM 438, Yeast Genetics and Molecular Biology; BIOES 470, Ecological Genetics; BIOMI 485, Bacterial Genetics, BIONB 423, Neurogenetics; BIONB 493, Developmental Neurobiology; BIOPL 343, Molecular Biology and Genetic Engineering of Plants.

Students may also choose from the following courses to complete the 13-credit requirement: BIOGD 682, Fertilization and Early Development; BIOGD 684, Advanced Topics in Population Genetics; BIOGD 687, Developmental Genetics; BIOBM 633, Biosynthesis of Macromolecules; BIOBM 639, The Nucleus; BIOES 663, Theoretical Population Genetics; BIOMI 694, Genetics of Diverse Bacteria; BIOPL 641, Laboratory in Plant Molecular Biology; BIOPL 644, Plant Growth and Development; BIOPL 652, Plant Molecular Biology II; BIOPL 653, Plant Molecular Biology I; PL BR 606, Advanced Plant Genetics.

Up to 3 credits for this program of study may be chosen from other biological sciences courses, including BIO G 499, Undergraduate Research in Biology, with approval of the faculty adviser.

7) *Microbiology:* BIOMI 290, General Microbiology, Lectures; BIOMI 291, General Microbiology, Laboratory; BIOMI 300, Seminar in Microbiology; BIOMI 391, Advanced Microbiology Laboratory; and at least 5 credits from the following course lists, including at least one course from each group: (a) BIOMI 485, Bacterial Genetics; or BIOMI 416, Microbial Physiology; and (b) BIOMI 415, Bacterial Diversity; or BIOMI 451, Structure and Function of Bacterial Cells.

8) *Neurobiology and Behavior:* The two-semester introductory course sequence, Neurobiology and Behavior I and II (BIONB 221 and 222) with discussion section (4 credits per term), and 7 additional credits, among which must be a course from the neurobiology and behavior offerings. BIONB 420, BIO G 498 and 499, and BIONB 720 may not be used as this neurobiology and behavior course. However, these readings and independent research courses may form part of the additional credits (beyond those provided by the advanced neurobiology and behavior course) required to complete the Program of Study in Neurobiology and Behavior.

Note: Students who declare the Program of Study in Neurobiology and Behavior after taking BIONB 221 or 222 for only 3 credits must complete additional course work in neurobiology and behavior. These students should consult the chair of the Section of Neurobiology and Behavior (W363 Seeley G. Mudd Hall) to determine what course(s) to use to make up the deficiency.

9) *Plant Biology:* Students choose one area of study from the following two options:

Option (a) *Botany:* Students are required to take Introductory Botany (BIOPL 241). Students should then choose, with the aid of their faculty adviser, a minimum of three of the following courses, for a total of at least 10 additional credits, to round out their botanical training: BIOPL 242 and 244, Plant Physiology, Lectures and Laboratory; BIOPL 246, Plants and Civilization; BIOPL 248, Taxonomy of Vascular Plants; BIOPL 342 and 344, Plant Physiology, Lectures and Laboratory; BIOPL 343 and 347, Molecular Biology and Genetic Engineering of Plants, Lectures and Laboratory; BIOPL 345, Plant Anatomy; BIOPL 359, Biology of Grasses; BIOPL 444, Plant Cell Biology; BIOPL 445, Photosynthesis; BIOPL 447, Molecular Systematics; BIOPL 448, Plant Evolution and the Fossil Record; BIOES 463 and 465, Plant Ecology and Population Biology, Lectures and Laboratory; or BIOES 466 and 468, Physiological Plant Ecology, Lectures and Laboratory.

Option (b) *Plant Biotechnology:* Students are required to take BIOPL 343 and 347, Molecular Biology and Genetic Engineering of Plants, Lectures and Laboratory. Students choose, in consultation with their faculty adviser, a minimum of 10 additional credits from the following list: BIOPL 241, Introductory Botany; BIOPL 242 and 244, Plant Physiology, Lectures and Laboratory; BIOPL 342 and 344, Plant Physiology, Lectures and Laboratory; BIOPL 346, Algal Physiology; BIOPL 444, Plant Cell Biology; BIOPL 648, Plant Biochemistry; PL BR 401, Plant Cell and Tissue Culture; or PL BR 402, Plant Tissue Culture Laboratory.

10) *Independent Option:* A special program for students interested in nutrition is available under this option. Students interested in courses in biophysics should contact the Office for Academic Affairs (200 Stimson Hall) for further information. In addition, students who want to undertake a

course of study not covered by the nine existing programs of study or the special program may petition the Division of Biological Sciences Curriculum Committee. Information on independent options and Curriculum Committee petition forms are available in the Office for Academic Affairs, 200 Stimson Hall.

Independent Research and Honors Program

Individual research projects under the direction of a faculty member are encouraged as an aspect of study within a program of study. Applicants for research projects are accepted by the individual faculty members, who take into account students' previous academic accomplishments, interests, and goals and the availability of space and equipment suitable for the proposed project. Students accepted for independent research enroll for credit in Biological Sciences (BIO G) 499 (Undergraduate Research in Biology) with the written permission of the faculty supervisor. Students register for this course in 200 Stimson Hall. Any faculty member in the Division of Biological Sciences may act as a supervisor. Faculty supervisors outside the division are acceptable only if a faculty member of the division agrees to take full responsibility for the quality of the work. Students may not earn credit for research conducted outside of Cornell. Information on faculty research activities and undergraduate research opportunities is available in the Behrman Biology Center, 216 Stimson Hall.

Research credits may not be used in completion of the following program of study areas: animal physiology; biochemistry; cell biology; ecology and evolutionary biology; microbiology; plant biology. Up to 3 credits of research may be used to complete the Program of Studies in general biology and genetics and development, and 4 credits of research in neurobiology and behavior.

The honors program in biological sciences is designed to offer advanced training in laboratory or field research through the performance of an original research project under the direct guidance of a member of the Cornell faculty. Applications for the honors program are available in the Office for Academic Affairs, 200 Stimson Hall, and must be submitted to the Honors Program Committee by the deadline announced early in the senior year. Application forms for the honors program are separate from the enrollment forms for Biological Sciences (BIO G) 499 (Undergraduate Research in Biology). To qualify for the program, students must have been accepted into the biological sciences major, have completed at least 30 credits at Cornell, and have an overall Cornell cumulative grade-point average of at least 3.00. In addition, students must have at least a 3.00 Cornell cumulative grade-point average in all biology, chemistry, mathematics, and physics courses. (Grades earned in courses in other departments that are used to fulfill major requirements are included in this computation.) In addition, candidates must have a Cornell faculty member to supervise their research. Any faculty member in the Division of Biological Sciences may act as a supervisor. Students may also work with Cornell faculty supervisors outside the division. Students who select supervisors outside the division must arrange for a faculty member of the division to serve as cosigner of the research. The division cosigner must agree to meet with the student on a regular basis, to report to the Honors Program Committee on the progress of the work approximately two months before the thesis is due, and to serve as a reviewer of the thesis. An honors candidate usually enrolls for credit in Biological Sciences (BIO G) 499 (Undergraduate Research in Biology) under the direction of the faculty member acting as honors supervisor, although it is not necessary to do so. Students choosing to earn credit for honors research must enroll in Biological Sciences (BIO G) 499 (Undergraduate Research in Biology) separate from the honors program. Requirements of the honors program include participation in honors research seminars during two semesters, submission of an acceptable honors thesis, completion of all major requirements, and maintenance of the 3.00 Cornell cumulative grade-point average through graduation. Recommendation to the faculty that a candidate graduate with honors and at what level of honors is the responsibility of the Honors Program Committee. The student's final grade point average is a factor in determining the level of honors recommended.

Students interested in the honors program should consult their faculty advisers early during their junior year. Students are strongly encouraged to begin their research projects in their junior year, although they are not formally admitted to the honors program until the beginning of their senior year. Students who are considering study abroad during their junior year should consult with a member of the Honors Committee during their sophomore year to plan a reasonable schedule for honors research. The Honors Program requires that student participants attend honors seminars in which they give oral presentations during the first and second semesters of their senior year. Therefore, students who are considering studying away from campus during the senior year should consult with a member of the Honors Committee no later than the beginning of the first semester of their junior year. Details pertaining to thesis due dates, seminars, and other requirements may be obtained from the chair of the Honors Program Committee or from the Office for Academic Affairs, 200 Stimson Hall. Information on faculty research activities is available in the Behrman Biology Center, 216 Stimson Hall. Deviation from any of the requirements of the Honors Program requires a petition in the form of a letter to the Honors Program Committee, c/o 200 Stimson Hall.

CURRICULUM COMMITTEE

Many decisions pertaining to the curriculum, to division-wide requirements, and to the programs of study are made by the Curriculum Committee of the division. The committee consists of faculty and elected student members and welcomes advice and suggestions from all interested persons.

ADVISING

Students in need of academic advice are encouraged to consult their advisers, come to the Behrman Biology Center (216 Stimson Hall), or contact the associate director for academic affairs (200 Stimson Hall).

Students interested in marine biology should visit the Cornell Marine Programs Office, G14 Stimson Hall.

Students interested in the multidisciplinary program Biology and Society should see "Special Programs and Interdisciplinary Studies," in the College of Arts and Sciences section of this catalog.

INDEX OF COURSES

The following course identifiers are used to denote biological sciences courses in specific areas: General Courses, BIO G; Animal Physiology, BIOAP; Biochemistry, Molecular and Cell Biology, BIOBM; Ecology and Systematics, BIOES; Genetics and Development, BIOGD; Microbiology, BIOMI; Neurobiology and Behavior, BIONB; Plant Biology, BIOPL; Shoals Marine Laboratory, BIOSM.

Note: Biological sciences courses count as agriculture and life sciences credits for students in the College of Agriculture and Life Sciences and as arts and sciences credits for students in the College of Arts and Sciences.

Course Index

GENERAL COURSES (BIO G)

The Division of Biological Sciences teaches three introductory biology course sequences during the academic year: Bio G 101–104, Bio G 105–106, and Bio G 109–110; and one during the eight-week summer session: Bio G 107–108. Bio G 101–104, 105–106, and 107–108 are intended for biological sciences majors and other students needing 8 credits from an introductory sequence for majors (for example, students in a premedical curriculum). Any of these sequences meets the prerequisite for upper-level courses listing "one year of introductory biology for majors" as a prerequisite. Bio G 109–110 is a course sequence intended for non-majors, and meets the prerequisite for many, but not all, upper-level courses listing "one year of introductory biology" as a prerequisite. Students can earn a maximum of 8 credits in introductory biology (including advanced placement credits).

BIO G 101–102 Biological Sciences, Lectures

101, fall; 102, spring. 2 credits each term. Prerequisite: concurrent enrollment in Bio G 103 (fall) or 104 (spring). Passing grade (D or better) in 101 is prerequisite to 102 unless permission is obtained from instructor. May not be taken for credit after Bio G 105–106 or 109–110. S-U grades optional, with permission of instructor. Lecs, M W F 9:05 or 10:10. 2 lecs each week; to accommodate these, students must reserve all 3 days. Evening prelims: fall, Sept. 26 and Nov. 12; spring, Feb. 20 and Apr. 3. K. K. Adler.

Designed both for students who intend to specialize in biological sciences and for those who want to obtain a thorough knowledge of biology as part of their general education. The fall semester covers the chemical and cellular basis of life, energy transformations, physiology, neurobiology, and behavior. The spring semester covers genetics, development, evolution, and ecology. Each topic is considered in the light of modern evolutionary theory and discussions of plant and animal systems are integrated.

BIO G 103–104 Biological Sciences, Laboratory

103, fall; 104, spring. 2 credits each term. Prerequisite: concurrent enrollment in BIO G 101 (fall) or 102 (spring). 103 is prerequisite to 104 unless permission is obtained from instructor. No admittance after second week of classes. S-U grades optional, with permission of instructor. Lab, M T W or R 1:25–4:25, M or W 7:30–10:30 p.m., or T R or S 8–11. One 3-hour lab each week and a weekly lec for discs, special lecs, etc. J. C. Glase, P. R. Ecklund, and staff.

BIO G 103–104 is designed to provide laboratory experience with major biological phenomena in order to support an understanding of the important concepts, principles, and theories of modern biology. A second objective of the laboratory course is to help students gain expertise in the methods used by biologists to construct new knowledge. Students are exposed to basic concepts, research methods, including laboratory and data transformation techniques, and instrumentation in the major areas of biology. First-semester topics include biochemistry, physiology, plant biology, and behavior. In the second semester, laboratory experience is provided in the areas of genetics, biotechnology, immunology, invertebrate diversity, population plant growth and development, and ecology. During the first semester, dissection of a doubly-pithed frog is included. Pithing is done by the instructor.

BIO G 105–106 Introductory Biology

105, fall; 106, spring. 4 credits each term (or 2 credits, with permission of instructor). Enrollment limited to 200 students. Prerequisite: 105 is prerequisite to 106, unless written permission is obtained from instructor. May not be taken for credit after BIO G 101–104 or 109–110. No admittance after first week of classes. Estimated cost for dissection kit, $11. S-U grades optional, with written permission of instructor. Lec, T 9:05 (1st lec of fall term, R 8/29 9:05); additional study and lab hours to be arranged. C. H. McFadden and staff.

Designed primarily for biology majors, preprofessionals, and other students who desire a challenging, broad introduction to fundamental concepts of biology. Physiology, anatomy (accompanied by preserved vertebrate and invertebrate dissection), and biochemistry are strongly emphasized in the fall semester. Subjects of study in the spring semester are genetics, development, ecology, evolution, behavior, and the diversity of organisms (accompanied by preserved vertebrate dissection). The course uses an autotutorial format and offers considerable flexibility in scheduling. Completion of the course requires mastery of a group of core units. Testing on these units is primarily by oral examination. Students who take the course must respect deadlines. Four formal laboratory sessions are offered each semester; additional laboratory work is included in the core units. Evaluation is based on written reports on experimental work or on extensive dissections (both vertebrate and invertebrate) with practical exams. Performance on the core units, the laboratories, and the final examination determine the final grade. Students who object to dissecting live invertebrates should talk to the instructor before registering.

BIO G 107–108 General Biology

Summer (8-week session; 107, weeks 1–4; 108, weeks 5–8). 4 credits each. Prerequisite: one year of college or permission of instructor; BIO G 101–103, 105, or 107 is a prerequisite for 108. Fee, $25 for weeks 1–4; $15 for weeks 5–8. Lecs, M-R 9–12; labs, M T R 1:30–4:30, F 9–12. Staff.

Designed for students who plan further study in biology and for students who want a broad course in biology as part of their general

education. BIO G 107 covers biological metabolism, first at the molecular level and then progressively to the organ system level. The laboratory work involves an introduction to some major techniques, vertebrate dissection, and a survey of plant organization. BIO G 108 seeks to integrate the topics of genetics, developmental biology, population biology, and ecology in a general consideration of biological evolution. The laboratory work is a continuation of the material covered in BIO G 107 and involves more techniques, a survey of animal organization, and the design and performance of a field study. BIO G 107–108 fulfills the introductory biology requirement for majors and forms a suitable introductory biology course sequence for students intending to go to medical school.

BIO G 109–110 Biological Principles
109, fall; 110, spring. 3 credits each term. Limited to 600 students. A passing grade in 109 or 101–103 or 105 is prerequisite to 110 unless *written* permission is obtained from the *instructor* and the student has at least 3 credits of college biology. Since 109–110 together constitute an integrated survey, 109 cannot be used to satisfy the College of Arts and Sciences or College of Agriculture and Life Sciences distribution requirement unless it is followed by 110 or an exemption is obtained from the instructor. May not be taken for credit after BIO G 101–104 or 105–106. This course sequence may be used to fulfill the distribution requirement in the Colleges of Agriculture and Life Sciences, Arts and Sciences, and Human Ecology but may *not* be used as an introductory course for the major in biological sciences. *Note that this course satisfies the prerequisite for many, but not all second- and third-level courses in biology.* Letter grade only. Lecs, M W F 9:05 or 10:10; lab, M T W R or F 2–4:25 or T 10:10–12:35. Students do not choose lab sections during course enrollment; lab assignments are made during first day of classes. Each student must attend lab on alternate weeks. Evening prelims: fall, Sept. 26 and Nov. 12; spring, Feb. 20 and Apr. 3. R. Turgeon, M. Taylor, C. Eberhard, and staff.
Students who do not plan to major in biology may take this broad introductory course in modern biology. It is not a course in social biology but addresses itself to biological principles with academic rigor. The content is designed to appeal to anyone who seeks a comprehensive knowledge of biology as part of a general education. Laboratory sections enable small groups of students to meet with the course staff and are used for problem-solving experiments, demonstrations, and discussions. No live dissections are involved; there are dissections of vertebrate and invertebrate material (observation required).

BIO G 152 Special Topics in Biology
Spring. 1 credit. Limited to 30 students. Prerequisites: superior performance in BIO G 109 or equivalent and concurrent enrollment in BIO G 102, 106, or 110, or written permission of instructor. S-U grades only. *This course may not be used in fulfillment of college distribution requirements.* Lec, T 3:35; occasional field trips to be arranged. Guest lecturers discuss topics in their field of research interest. R. Turgeon, C. Eberhard, staff, and guest lecturers.
This course is designed to complement introductory biology by providing an opportunity for deeper exploration of selected topics of interest. Class involvement and discussion are encouraged.

BIO G 170 Evolution of the Earth and Life (also Geological Sciences 102)
Spring. 3 credits. Recommended: GEOL 101. S-U grades optional. Lecs, T R 9:05 or 11:15; lab, M T W or R 2:00–4:25; field trips during lab. J. L. Cisne.
Earth systems and their evolution. Earth history's astronomical context. Plate tectonics, continental drift, and their implications for climate and life. Coevolution of life and the atmosphere. Precedents for ongoing global change. Dinosaurs; mass extinctions; human ancestry. Laboratories on reconstructing geological history and mapping ancient geography. Fossil-collecting on field trips.

BIO G 200 Special Studies in Biology
Fall, spring, or summer. 1–3 credits. Prerequisites: transfer- or special-student status and written permission of instructor and of the associate director of the Division of Biological Sciences. Students must register using a special form available in Stimson 200. S-U grades optional, with permission of instructor. Hours to be arranged. Staff.
A registration device for students who want to take only a portion of a regular biological sciences course—for example, only the lectures or only the laboratory in a course that includes both. Only students who have already had training equivalent to the portion of the regular course that is to be omitted may register in this manner. This course may not be substituted for 100–level courses and may not be used in fulfillment of college distribution requirements except by permission of the associate director of the division.

BIO G 207 Evolution (also History 287 and Science and Technology Studies 287)
Fall or summer. 3 credits. Intended for students with no background in college biology. May not be taken for credit after BIOES 278. Does not meet the evolutionary biology requirement for the biological sciences major. S-U grades optional. Fall: Lecs, T R 10:10; disc, 1 hour each week to be arranged. W. B. Provine. Summer: Lecs/disc, M-F 8:30–9:45. A. S. Kondrashov.
Evolution is the central concept in biology. This course examines evolution in historical and cultural contexts. Aims of the course include understanding the major issues in the history and current status of evolutionary biology, and exploration of the implications of evolution for culture. Issues range from controversies over mechanisms of evolution in natural populations to the conflict between creationists and evolutionists.

BIO G 208 Drawing the Human Figure
Summer (6-week session). 3 credits. Labs, M T W 3:00–5:15. K. Kucharski.
Human anatomy. Emphasis on learning correct anatomical information relating to the skeletal and muscular systems as approached through observation and drawing practices.

BIO G 209 Introduction to Natural Science Illustration
Summer (6-week session). 2 credits. Limited to 12 students. Prerequisite: free-hand drawing or permission of instructor. S-U grades optional. Lecs and labs, T R 6:30–9:30 p.m. B. S. King.
An introduction to the art of natural science illustration for publication, and to the techniques of various media including pencil, pen and ink, watercolor, colored pencil, scratchboard, and carbon dust. Potentials and limitations of line and half-tone reproduction, copyright, and portfolio presentation are discussed.

BIO G 305 Basic Immunology Lectures (also Veterinary Microbiology 315)
Fall. 3 credits. Strongly recommended: basic courses in microbiology, biochemistry, and genetics. S-U grades optional, with permission of instructor. Lecs, T R 8:30–9:55. J. A. Marsh.
A survey of immunology, with emphasis on the biological functions of the immune response.

BIO G 400 Undergraduate Seminar in Biology
Fall or spring. Variable credit (1–3 credits assigned for individual seminar offerings). May be repeated for credit. S-U grades optional. Sem to be arranged. Staff.
From time to time specialized seminars on topics of interest to undergraduates are offered by visiting faculty or faculty from the Sections of Ecology and Systematics, Genetics and Development, or Plant Biology. Topics and instructors are listed in the division's catalog supplement issued at the beginning of the semester. For students interested in Biochemistry, Physiology, or Neurobiology, please see descriptions under appropriate section.

[BIO G 401 Introduction to Scanning Electron Microscopy
Fall or spring, weeks 1–8. 1 credit. Limited to 8 students (fall), 12 students (spring). Prerequisite: permission of instructor. S-U grades optional. Not offered fall 1996; next offered spring 1997. Lec, M 10:10; lab, T R or F 9:05–12:15 or T W or R 1:25–4:25. Fee may be charged. M. V. Parthasarathy.
An introductory course that includes the principle and use of the scanning electron microscope. Students use biological material to explore and understand some of the fine biological architecture. In addition to preparing the specimens, the students use the scanning electron microscope to study and obtain micrographs of features that interest them.]

[BIO G 403 Transmission Electron Microscopy for Biologists
Fall. 1, 3, or 4 credits (4 credits if student takes both sections). Limited to 12 students. Prerequisites: BIOAP 313, BIOPL 345 or 443, or written permission of instructor. S-U grades optional. Not offered 1996–97; next offered fall 1997. Lec, T 11:15; labs, M W or T R 1:25–4:25. Two sections: Sec 01, 1 credit, weeks 1–4; sec 02, 3 credits, weeks 5–12. Students may register for one or both sections. Fee may be charged. M. V. Parthasarathy.
Section 01, 1 credit, weeks 1–4, covers the principles and use of the transmission electron microscopy (TEM), with emphasis on proper operation of the instrument and interpretation of images obtained. Negatively stained materials are used for viewing with the transmission electron microscope. Section 02, 3 credits, weeks 5–12, covers the principles and techniques of preparing biological

material for transmission electron microscopy. Using animal, plant, and microbe materials this section studies chemical fixtures, cryofixations, ultrathin sectioning, immunogold localization, quantitative microscopy, and metal shadowing techniques. Students have two additional weeks to complete laboratory assignments at the end of each section.]

BIO G 405 Neotropics: Introduction to Their Biology

Fall. 2 credits. Limited to 18 students. Prerequisites: BioES 261 or equivalent, and permission of instructor. Sem, W 7:30–9:30 p.m. A. S. Flecker, P. H. Wrege, J. B. Heiser.

This seminar is an introductory survey of the biology of selected biomes of the New World tropics, with primary focus on moist lowland forests. The objectives are to learn the basic characteristics and phenomena important to an understanding of neotropical biology, to gain firsthand knowledge of the resources available at Cornell for the pursuit of this knowledge, and to learn (through doing) how to organize and execute a meaningful seminar presentation. Students read assignments from the two texts for the course. Additional readings are available if background material is needed or if the students have an area of special interest. In addition, each student participates in the design, organization, and presentation of one unit of course work. This may include arranging class visits to various Cornell resource facilities for the study of tropical biology, arranging for guest speakers, presenting additional material from the literature, and interviewing members of the Cornell community with experience or expertise relevant to that unit's topic. Selected films may also be presented.

BIO G 450 Light and Video Microscopy for Biologists

Spring. 3 credits. Limited to 12 students. Prerequisites: one year of introductory biology and permission of instructor. Lecs, T R 1:25–2:30; lab, R 2:30–4:30. R. O. Wayne.

Theoretical and practical aspects of light microscopy, including brightfield, darkfield, phase-contrast, polarization, Hoffman-modulation contrast, interference, differential-interference contrast, and fluorescence microscopy, as well as video- and computer-based digital image enhancement, are studied. Students learn both qualitative and quantitative techniques to probe noninvasively the structure and function of living plant cells.

[BIO G 467 Seminar in the History of Biology (also History 415, Biology and Society 447, and Science and Technology Studies 447)

Fall. 4 credits. Limited to 18 students. Prerequisite: permission of instructor required; register for course in Corson E139. Sem, T R 12:20–2:15 p.m. Not offered 1996–97. W. B. Provine.

Specific topic changes each year. Readings from scientists and historians, sociologists, and philosophers of science. The course helps students to evaluate assertions that the synthesis remains robust and assertions that the synthesis has disintegrated.]

BIO G 469 Food, Agriculture, and Society (also Biology and Society 469 and Science and Technology Studies 469)

Spring. 3 credits. Limited to 20 students. Prerequisite: an introductory ecology course or permission of instructor. S-U grades optional. Lecs, T R 1:25–2:40. A. G. Power.

A multidisciplinary course dealing with the social and environmental impact of food production in the United States and developing countries. Agroecosystems of various kinds are analyzed from biological, economic, and social perspectives. The impacts of traditional, conventional, and alternative agricultural technologies are critically examined in the context of developed and developing economies. Specific topics include pest management, soil conservation, plant genetic resources, biotechnology, and sustainable development.

BIO G 498 Teaching Experience

Fall or spring. 1–4 credits. Enrollment limited. Prerequisites: previous enrollment in the course to be taught or equivalent, and written permission of instructor. *Students in the College of Arts and Sciences may not count credits from this course toward the 120 credits required for graduation.* S-U grades optional, with permission of instructor. Hours to be arranged. Staff.

Designed to give qualified undergraduate students teaching experience through actual involvement in planning and assisting in biology courses. This experience may include supervised participation in a discussion group, assisting in a biology laboratory, assisting in field biology, or tutoring. Biological sciences courses currently offering such experience include BIO G 105–106; BIOAP 311, 319; BIOBM 231, 330, 331; BIOES 274, 475; and BIOMI 291, 292.

BIO G 499 Undergraduate Research in Biology

Fall or spring. Variable credit. *Students in the College of Arts and Sciences may not register for more than 6 credits per term with one supervisor or 8 credits per term with more than one supervisor.* Prerequisite: written permission of staff member who supervises the work and assigns the grade. *Students must register in the Office for Academic Affairs in 200 Stimson Hall.* Each student must submit an independent study statement describing the proposed research project during course registration. (Special forms for this purpose are available in the college offices and in 200 Stimson Hall.) Any faculty member in the Division of Biological Sciences may act as a supervisor. Cornell faculty supervisors outside the division are acceptable only if a faculty member of the division agrees to serve as cosigner, taking full responsibility for the quality of the work. Supervisors outside of Cornell are not acceptable. S-U grades optional. Hours to be arranged. Staff.

Practice in planning, conducting, and reporting independent laboratory and library research programs. Research credits may *not* be used in completion of the following programs of study: animal physiology; biochemistry; cell biology; ecology and evolutionary biology; microbiology; plant biology. Up to 3 credits of research may be used to complete the Program of Studies in general biology and genetics and development, and 4 credits of research in neurobiology and behavior.

BIO G 606 Freeze-Fracture Technique

Spring, weeks 9–14. 1 credit. Primarily for graduate students. Limited to 8 students. Prerequisites: BIO G 403 or equivalent, and permission of instructor. S-U grades only. Lec, M 10:10; disc to be arranged; labs, M W 1:25–4:25. Fee may be charged. M. V. Parthasarathy.

Principles of freeze-fracturing and freeze-substitution technique, freezing artifacts, and interpretation of images.

[BIO G 705 Advanced Immunology Lectures (also Veterinary Microbiology 705)

Spring. 3 credits. Prerequisite: BIO G 305 or permission of instructor. Offered alternate years. Not offered 1996–97. Lecs, M W F 9:05. Coordinator: R. G. Bell.

Coverage at an advanced level of molecular and cellular immunology.]

BIO G 706 Immunology of Infectious Diseases and Tumors (also Veterinary Microbiology 719)

Spring. 2 credits. Prerequisite: BIO G 305 or permission of instructor. S-U grades optional, with permission of instructor. Offered alternate years. Lec, R 10:10–12:05. Coordinator: R. G. Bell.

Coverage at an advanced level of the immunology of diseases caused by selected bacteria, viruses, protozoa, and helminthis, and tumor immunology.

Related Courses in Other Departments

The Sea: An Introduction to Oceanography (Biological Sciences [BIOES] 154)

Medicine and Civilization (Biology and Society 322)

Pathogenic Bacteriology and Mycology (Biological Sciences [BIOMI] 304 and Veterinary Microbiology 318)

Viruses and Disease (Biological Sciences [BIOMI] 408 and Veterinary Microbiology 408)

ANIMAL PHYSIOLOGY (BIOAP)

BIOAP 212 Human Physiology for Non-Biology Majors

Spring. 3 credits. May not be taken for credit after BIOAP 311. Limited to 130 students. This course may be used toward the science distribution requirement of the College of Arts and Sciences and the Group B distribution requirement of the College of Agriculture and Life Sciences. This course may not be used to fulfill the requirements of any Program of Study in the biological sciences major. Lecs, M W F 1:25; disc, M W or F 2:15. Evening prelims: Feb. 27 and Apr. 15. P. W. Concannon and staff.

Introduction to the physiology of all major organ systems and the relation of that physiology to human health and disease. Emphasis on understanding of major body functions and control mechanisms regulating each organ system. Students develop a fundamental understanding of how their bodies work that will be the basis of making informed decisions about their own health and medical needs and those of their families. Taught by staff of research physiologists and cooperating physicians.

BIOAP 214 Biological Basis of Sex Differences (also Biology and Society 214 and Women's Studies 214)

Fall. 3 credits. Limited to non-biology majors and freshman and sophomore biology majors; junior and senior biology majors may register with permission of instructor. Prerequisite: one year of introductory biology. S-U grades optional. Offered alternate years. Lecs, T R 8:30–9:55; occasional discussion to be arranged. J. E. Fortune.

The structural and functional differences between the sexes are examined. Emphasis is placed on mechanisms of mammalian reproduction; where possible, special attention is given to studies of humans. Current evidence on the effects of gender on nonreproductive aspects of life (behavior, mental, and physical capabilities) is discussed. The course is intended to provide students with a basic knowledge of reproductive endocrinology and with a basis for objective evaluation of sex differences in relation to contemporary life.

BIOAP 311 Introductory Animal Physiology, Lectures (also Veterinary Physiology 346)

Fall. 3 credits. Prerequisites: one year of college biology, chemistry, and mathematics. Recommended: previous or concurrent course in physics. S-U grades optional, with permission of instructor. Lecs, M W F 11:15. Evening prelims: Sept. 24 and Oct. 31. E. R. Loew and staff.

A general course in animal physiology emphasizing principles of operation, regulation, and integration common to a broad range of living systems from the cellular to the organismal level. Structure/function relationships are stressed along with underlying physico-chemical mechanisms.

BIOAP 312 Farm Animal Behavior (also Animal Science 305)

Spring. 2 credits. Prerequisites: introductory course in animal physiology. Recommended: at least one animal production course or equivalent experience. S-U grades optional. Lecs, T R 11:15. E. A. Oltenacu, K. A. Houpt.

The behavior of production species (avian and mammalian) influences the success of any management program. Students study behaviors relating to communication, learning, social interactions, reproduction, and feeding of domestic animals, and their physiological basis. Management systems for commercial livestock production and their implications for animal behavior and welfare are stressed.

BIOAP 313 Histology: The Biology of the Tissues

Fall. 4 credits. Prerequisite: one year of introductory biology. Recommended: BIOBM 330 or 331, or their equivalents; and previous or concurrent enrollment in BIOAP 311. S-U grades optional, with permission of instructor. Lecs, T R 1:25; labs, T R 2:30–5:00. C. Wahl.

Provides students with a basis for understanding the microscopic, fine-structural, and functional organization of vertebrates, as well as methods of analytic morphology at the cell and tissue levels. Dynamic interrelations of structure, composition, and function in cells and tissues are emphasized. The course may include work with vertebrate animals.

BIOAP 316 Cellular Physiology

Spring. 4 credits. Limited to 72 students, with preference given to students studying in animal physiology. Each lab limited to 36 students. Prerequisite: concurrent or previous enrollment in BIOBM 330 or 331 and 332 or 333. Lecs, M W F 9:05; lab, M or T 1:25–5:00. Evening prelims: Feb. 25, Apr. 3, and April 29. A. Quaroni and staff.

Lectures introduce students to the most current information on the way cells function and regulate themselves and neighboring cells and on what molecules are involved in these regulatory processes. Laboratories provide an introduction to cell and organ culture and to immunological techniques used to study cell structure and function *in vivo* and *in vitro*. Experiments performed in the laboratory are closely related to, and provide practical experience with, subjects covered in the lectures. Vertebrate animals are used in this course. No experimentation is performed on live animals.

BIOAP 319 Animal Physiology Experimentation

Fall. 4 credits. Designed for upper-level undergraduate and graduate students studying in physiology, and other students interested in biomedically related professions. Graduate students in the Field of Physiology and related fields without equivalent background are strongly encouraged to enroll. Each of 3 afternoon laboratory sections limited to 32 students. Prerequisite: concurrent or previous enrollment in BIOAP 311 or permission of instructor based on previous meritorious performance in another introductory animal physiology course. Lec, R 12:20; lab, M W or F 12:20–5:00 (includes disc section). R. A. Corradino.

A series of student-conducted *in vitro* and *in vivo* experimental exercises designed to illustrate basic physiological processes in animals and to introduce students to animal physiology research techniques, instrumentation, experimental design, and interpretation of results. Techniques include anesthesia, dissection, vivisection under anesthesia, physiographic and computer recording and analysis. Experiments with living tissues and live animals examine properties of blood, muscle, and nerves; cardiovascular, respiratory, and renal function and their control; and endocrine regulation of renal, cardiovascular, and reproductive tissue activity. Experimental resources include live animals of several vertebrate species, including frogs, rats, and rabbits, which are euthanized in conjunction with the laboratory exercises. Written reports of laboratory activities are required. Grading is based on evaluation of these reports, quizzes, and laboratory performance.

BIOAP 419 Advanced Animal Physiology Experimentation

Spring. 3 credits. Prerequisite: BIOAP 319 previous semester. Limited to 12 selected students. Lab to be arranged. Coordinator: R. A. Corradino.

Advanced research on selected aspects of laboratories conducted in BIOAP 319, Animal Physiology Experimentation.

BIOAP 458 Mammalian Physiology

Spring. 3 credits. Enrollment limited. Graduate student auditors allowed. Prerequisite: BIOAP 311 or equivalent. Students not meeting this prerequisite must obtain written permission of instructor in T9 026 Vet Research Tower before the first class. Lecs, M W F 10:10. Evening prelims: Feb. 18, Mar. 25, and Apr. 22. K. W. Beyenbach and staff.

The course offers an in-depth treatment of selected topics in mammalian and human physiology. Emphasis is on concepts and a working knowledge of physiology. Selected topics include: basic functional elements of biological systems; recurrent themes in physiology; design of multicellular animals; mammalian fluid compartments; homeostasis; membrane and epithelial transport; electrophysiology; cardiovascular physiology, gastrointestinal physiology; renal physiology; and acid/base physiology. The lectures incorporate clinical correlations whenever appropriate. Occasional guest lecturers talk about work and careers in basic research and/or clinical medicine. Recommended for biological sciences majors, pre-med and pre-vet students, and beginning graduate students in physiology, nutrition, and animal science.

BIOAP 619 Lipids (also Nutritional Sciences 602)

Fall. 2 credits. Lecs, T R 11:15. A. Bensadoun.

Advanced course on biochemical, metabolic, and nutritional aspects of lipids. Emphasis is placed on critical analysis of current topics in lipid methodology; lipid absorption; lipoprotein secretion, molecular structure, and catabolism; molecular biology, function and regulation of lipoprotein receptors; mechanism of hormonal regulation of lipolysis and fatty acid synthesis; and cholesterol metabolism and atherosclerosis.

[BIOAP 658 Molecular Mechanisms of Hormone Action

Spring. 2 credits. Prerequisite: permission of instructor. Minimum enrollment of 6 required. Offered alternate years. Not offered 1996–97. Lecs, T R 10:10. R. A. Corradino.

An advanced course developed from the current literature on endocrine mechanisms. Primarily a lecture course with student discussion.]

BIOAP 710–718 Special Topics in Physiology

Fall or spring. 1 or 2 credits for each topic. May be repeated for credit. Enrollment in each topic may be limited. S-U grades optional, with permission of instructor. Lectures, laboratories, discussions, and seminars on specialized topics. Two topics offered fall 1996; one topic offered spring 1997.

BIOAP 711 Stress Physiology: to be discussed as part of animal welfare

Fall. 1 credit. Prerequisite: BIOAP 311 or equivalent. Offered alternate years. Lec, 1 hour each week to be arranged. K. A. Houpt.

Emphasis is on physiological assessment of stress.

BIOAP 712 Proteolysis in Physiological Function and Dysfunction (also VET MED 686)

Spring. 1 credit. Offered alternate years. Lec, 1 hour each week to be arranged. J. F. Wootton.

BIOAP 713 Cardiac Electrophysiology

Fall. 1 credit. Offered alternate years. Lec, 1 hour each week to be arranged. R. F. Gilmour.

Survey of cardiac action potentials, passive membrane properties, ion channels, and

cardiac arrhythmias. Emphasis on non-linear dynamical aspects of cardiac electrophysiology and cardiac arrhythmias.

BIOAP 719 Graduate Research in Animal Physiology (also Veterinary Physiology 628)
Fall or spring. Variable credit. Prerequisites: written permission of the section chair and of the staff member who supervises the work and assigns the grade. Students must register in Vet Research Tower 825. S-U grades optional. Hours to be arranged. Staff.
Similar to BIO G 499 but intended for graduate students who are working with faculty members on an individual basis.

BIOAP 757 Current Concepts in Reproductive Biology
Fall. 3 credits. Limited to 20 students. Prerequisites: undergraduate degree in biology and a strong interest in reproductive biology. S-U grades optional. Offered alternate years. Lec, 2 hours each week to be arranged; disc, 1 hour each week to be arranged. J. E. Fortune, W. R. Butler, and staff.
A team-taught survey course in reproductive physiology/endocrinology. Lectures by a number of reproductive biologists on various aspects of male reproductive function (endocrine regulation, testis function, spermatogenesis, and sperm physiology/function); female reproductive function (endocrinology, ovarian development and functions, oocyte physiology/function); fertilization and early embryo development; pregnancy; parturition; puberty; and reproductive technology. Student participation in the form of discussions and/or presentations.

BIOAP 811 Advanced Physiological Methods I
Fall. 2 credits. Enrollment limited. Prerequisites: graduate student status or permission of course coordinator. S-U grades only. Lab to be arranged. Coordinator: P. W. Nathanielsz.
This is a course primarily for graduate students in physiology and related disciplines. Experiments are carried out in the laboratories of physiology faculty members to acquaint graduate students with the latest techniques/methods in physiological research. Three modules are offered each semester by arrangement with the course coordinator.

BIOAP 812 Advanced Physiological Methods II
Spring. 2 credits. Enrollment limited. Prerequisites: graduate student status or permission of course coordinator. S-U grades only. Lab to be arranged. Coordinator: P. W. Nathanielsz.
This is a course primarily for graduate students in physiology and related disciplines. Experiments are carried out in the laboratories of physiology faculty members to acquaint graduate students with the latest techniques/methods in physiological research. Three modules are offered each semester by arrangement with the course coordinator.

Related Courses in Other Departments

Adaptations of Marine Organisms (Biological Sciences [BIOSM] 413)

Advanced Work in Animal Parasitology (Veterinary Microbiology 737)

Animal Development (Veterinary Anatomy 507)

Animal Reproduction and Development (Animal Science 300)

Developmental Biology (Biological Sciences [BIOGD] 385)

Embryology (Biological Sciences [BIOGD] 389)

Fundamentals of Endocrinology (Animal Science 427)

Insect Morphology (Entomology 322)

Integration and Coordination of Energy Metabolism (Biological Sciences [BIOBM] 637 and Nutritional Sciences 636)

Neuroanatomy (Veterinary Anatomy 504)

Sensory Function (Biological Sciences [BIONB] 492)

Teaching Experience (Biological Sciences [BIO G] 498)

Undergraduate Research in Biology (Biological Sciences [BIO G] 499)

BIOCHEMISTRY, MOLECULAR AND CELL BIOLOGY (BIOBM)

BIOBM 132 Orientation Lectures in Biochemistry
Spring, weeks 1–3. No credit. Primarily for freshmen, sophomores, and transfer students. S-U grades only (registered students receive an unsatisfactory grade for nonattendance). Lec, S 10:10–11:00, for first three S of semester. Section chair and staff.
Discussions by six professors about their research and promising areas for research in the future.

[BIOBM 231 General Biochemistry
Fall. 3 credits. Not offered 1996–97. Staff.]

BIOBM 233 Introduction to Biomolecular Structure
Fall. 2 credits. Limited to 30 students. Prerequisites: CHEM 207–208 or equivalents. Lecs, T R 2:30–3:20. S. E. Ealick.
This course is intended for students with a basic understanding of chemistry who are considering a program of study in biochemistry. The interrelationship between the structure and function of biologically important molecules are explored. Emphasis is placed on understanding the way in which the three-dimensional arrangements of atoms determine the biological properties of both small molecules and macromolecules such as proteins and enzymes. The study of molecular structure is aided by interactive computer graphics for visualizing three-dimensional structures of molecules.

[BIOBM 234 Recombinant DNA Applications, Discussion
Spring. 1 credit. Concurrent registration in BioBM 232 required. Limited to 16 students in each section. S-U grades optional. Not offered 1996–97.
Applications discussed include screening for genetic diseases, HIV and other maladies; gene therapies; DNA fingerprinting; agricultural uses—animals, plants, and food products; and drugs, diagnostics, and vaccines. Social, ethical, legal, and economic issues are discussed as well as new linkages between agriculture and medicine.]

BIOBM 320 Physics of Life (also Applied and Engineering Physics 320)
Spring. 3 credits. Prerequisites: freshman and sophomore chemistry, physics, math. S-U grades optional. Lecs, T R 10:10–11:25; lab/field trips/discussions to be arranged. L. Jelinski.
A foundations course for students interested in biophysics and bioengineering.

BIOBM 330–332 Principles of Biochemistry
Introductory biochemistry is offered in three formats: individualized instruction (330) and lectures (331 and 332) during the academic year and lecture (333) during the summer. *Individualized instruction is offered to a maximum of approximately 200 students each semester. Lectures given fall semester (331) and spring semester (332).*

BIOBM 330 Principles of Biochemistry, Individualized Instruction
Fall or spring. 4 credits. Prerequisites: one year of introductory biology for majors and one year of general chemistry and CHEM 253 or 257 or 357–358 or equivalent, or permission of instructor. Concurrent registration in BIOBM 334 is encouraged. May not be taken for credit after BIOBM 331, 332, or 333. S-U grade optional for graduate students only. Hours to be arranged. Evening prelims: fall, Oct. 22; spring, Mar. 11. J. E. Blankenship, G. S. Albrecht, P. C. Hinkle, R. Wu, and staff.
Fourteen units that cover protein structure and function, enzymes, basic metabolic pathways, DNA, RNA, protein synthesis, and an introduction to gene cloning. No formal lectures; autotutorial format; discussion sessions on three research papers on protein structure and function.

BIOBM 331 Principles of Biochemistry: Proteins and Metabolism
Fall. 3 credits. Prerequisites: one year of introductory biology for majors and one year of general chemistry and CHEM 253 or 257 or 357–358 or equivalent, or permission of instructor. May not be taken for credit after BIOBM 330 or 333. S-U grades with permission of instructor. Lecs, M W F 10:10. Evening prelim: Oct. 22. G. W. Feigenson.
The chemical reactions important to biology, and the enzymes that catalyze these reactions, are discussed in an integrated format. Topics include methods for studying proteins, protein folding, enzyme catalysis, bioenergetics, and key reactions of synthesis and catabolism.

BIOBM 332 Principles of Biochemistry: Molecular Biology
Spring. 2 credits. Prerequisites: one year of introductory biology for majors and previous or concurrent registration in organic chemistry, or permission of instructor. May not be taken for credit after BIOBM 330 or 333. S-U grades optional, with permission of instructor. Lecs, T R 12:20. J. M. Calvo.
A comprehensive course in molecular biology that covers the structure and properties of DNA, DNA replication and recombination, synthesis and processing of RNA and proteins, the regulation of gene expression, and the principles and uses of recombinant DNA technologies.

BIOBM 333 Principles of Biochemistry: Proteins, Metabolism, and Molecular Biology

Summer (6-week session). 4 credits. Prerequisites: one year general chemistry and CHEM 253 or 257, or 358, or equivalents, or permission of the instructor. May not be taken for credit after BIOBM 330, 331, or 332. S-U grades with permission of instructor. Lecs, M–F 10:00–12:00. H. T. Nivison.

The content of this course is similar to that of BIOBM 330; however, it is presented in lecture format rather than as individualized instruction. The topics include the structure and function of proteins, enzyme catalysis, metabolism, and the replication and expression of genes.

BIOBM 334 Computer Graphics and Molecular Biology

Fall or spring. 1 credit. Prerequisite: concurrent registration in BIOBM 330 or written permission of instructor. May not be taken for credit after BIOBM 331, 332, or 333. Disc to be arranged. J. E. Blankenship, G. S. Albrecht, P. C. Hinkle, A. Karplus, and staff.

Visualization of complex biomolecules using Silicon Graphics computers. Student presentations on current topics in molecular biology.

BIOBM 432 Survey of Cell Biology

Spring. 3 credits. Prerequisite: BIOBM 330, 333, or 331, and previous or concurrent registration in 332, or equivalent. S-U grades optional for graduate students only. Lecs, M W 8:40–9:50. W. J. Brown and staff.

A survey of a wide array of topics focusing on the general properties of eucaryotic cells. The topics include methods used for studying cells, the structure and function of the major cellular organelles, and analyses of cellular processes such as mitosis, endocytosis, cell motility, secretion, cell-to-cell communication, gene expression, and oncogenesis. Some of the material is covered in greater depth in BIOBM 437; BIOGD 483; BIOBM 632, 636, and 639.

BIOBM 434 Biotechnology: Molecular Basis

Summer (6-week session). 3 credits. Prerequisite: BIOBM 330 or 331 and 332 or 333, or equivalent. Lec to be arranged. S. Ely.

This course provides a detailed account of the biochemistry and molecular biology behind recent biotechnological advances and commercial introductions. Topics include the use of transgenic bacteria in bioremediation and for insect control, of transgenic plants to provide novel biopesticide delivery and protection systems, and the engineering of plants and animals for production of pharmaceutical and other valuable materials.

BIOBM 435–436 Undergraduate Biochemistry Seminar

435, fall; 436, spring. 1 credit each term. May be repeated for credit. Limited to upperclass students. Prerequisite: BIOBM 330 or 333 or 331 and 332 or written permission of instructor. S-U grades only. Sem to be arranged. Organizational meeting first W of each semester at 4 p.m. Fall: G. P. Hess; spring: staff.

Selected papers from the literature on a given topic are evaluated critically during six or seven two-hour meetings.

BIOBM 437 Oncogenes and Cancer Viruses (also Toxicology 437)

Fall. 3 or 4 credits (4 credits for participation in the writing component of the course). Undergraduates are required to do the 4-credit option. Prerequisite: BIOBM 330 or 333 or 331 and 332. Recommended: BIOGD 281. S-U grades optional. Lecs, T R 12:20–1:35; disc, W 7:30 p.m. D. I. Shalloway.

The use of animal cells in culture as an experimental system for studying the cellular mechanisms involved in carcinogenesis through the use of recombinant DNA and biochemical methods. Topics include immortalization of cells, the cell cycle, differences between normal and neoplastically transformed cells, growth factors, molecular biology and biochemistry of cancer viruses, and structure and function of viral and cellular oncogenes. Understanding of relevant experimental techniques, experimental design, and comprehension of primary research literature is emphasized. This is *not a survey course*; it is designed primarily for students planning a career in research. A series of exercises to develop scientific writing skills are required for undergraduate students except by special permission. Depending on availability, graduate students may also participate in this writing component. Four credits are given when the writing component is included.

BIOBM 438 Yeast Genetics and Molecular Biology

Spring. 2 credits. Prerequisites: BIOGD 281 and BIOBM 330 or 332 or 333, or permission of instructor. S-U grades optional. Offered alternate years. Lec. W 8–9:55 p.m. B.-K. Tye.

An advanced overview of genetic studies in yeast, primarily *Saccharomyces cerevisiae*. Special attention is given to the use of yeast as a model for studying problems in cell biology in eukaryotes. Both genetic and molecular approaches to selected problems of biological interest are discussed.

BIOBM 630 Laboratories in Biochemistry, Molecular, and Cell Biology (formerly BIOBM 630, Experimental Cell Biology; BIOBM 634, Experimental Proteins and Enzymology; and BIOBM 638, Experimental Molecular Biology)

Fall or spring. 2 or 4 credits (students are expected to sign up for two sections for a total of 4 credits; limited space available for students taking only one section). Enrollment limited. Prerequisites: BIOBM 330, or 331 and previous or concurrent enrollment in 332, or 332 and previous or concurrent enrollment in 331, or 333, and permission of instructor obtained by filling out an enrollment form (available in 301C Rice Hall). Strongly recommended: BIOGD 281. Class assignments are affected by date enrollment forms returned to 301C Rice Hall. Preference given to undergraduate majors in the Biochemistry or Cell Biology Program of Study, and to graduate students with a minor in the Field of Biochemistry, Molecular and Cell Biology. Labs, M W 12:20–4:25 (disc, one hour F afternoon to be arranged) or T 9:05–4:25 (disc, one hour R morning to be arranged) or R 9:05–4:25 (disc, one hour T afternoon to be arranged.) Each section is seven weeks during the semester; the dates to be determined at the beginning of each semester depending on scheduling constraints and student preferences.

Section 01 Experimental Molecular Biology

2 credits. H. T. Nivison, B. Tyler, V. M. Vogt.

Experiments include cloning of DNA fragments, restriction mapping, DNA sequencing, Southern blotting, and PCR. The experiments emphasize quantitative aspects as well as experimental design.

Section 02 Experimental Proteins and Enzymology

2 credits. H. T. Nivison, B. Tyler, V. M. Vogt.

Experiments include purification of enzymes by ion exchange chromatography and affinity chromatography, determination of kinetic parameters for an enzyme, analysis of proteins by rate zonal sedimentation, SDS-polyacrylamide gel electrophoresis, and immunoblotting.

Section 03 Experimental Cell Biology

2 credits. T. Huffaker, B. Tyler.

Experiments include culture of animal cells, transfection, immunofluorescence microscopy, and evaluation of cellular stress responses using radioisotope labeling methods.

BIOBM 631 Protein Structure and Function

Fall. 3 credits. Prerequisites: BIOBM 330 or 333 or 331 and 332, physical chemistry, and organic chemistry. S-U grades optional. Lecs, M W F 9:05. L. Nicholson.

Presentations on the principles of protein structure and the nature of enzymatic catalysis. Specific topics include protein folding, stability, dynamics and evolution, folded conformations and structure prediction, ligand binding energetics, and the structural basis of catalysis.

[BIOBM 632 Membranes and Bioenergetics

Spring. 2 credits. Prerequisite: BIOBM 330 or 333 or 331 and 332 or equivalent. Offered alternate years. Not offered 1996–97. Lecs, T R 11:15. P. C. Hinkle.

Structure and dynamics of biological membranes, physical methods, model membranes, ionophores, ion-transport ATPases, mitochondrial and chloroplast electron transfer chains, and examples of transport from plants, animals, and bacteria. Emphasis given to structure of membrane proteins.]

BIOBM 633 Biosynthesis of Macromolecules

Fall. 2 credits. Prerequisite: BIOBM 330 or 333 or 331 and 332. Recommended: BIOGD 281. Lecs, T R 9:05. J. W. Roberts, D. B. Wilson.

Synthesis of DNA, RNA, and proteins, and regulation of gene expression.

BIOBM 635 Mechanisms of Metabolic Regulation and Mammalian Gene Expression (also Nutritional Sciences 635)

Spring. 2 credits. Prerequisites: at least 4 credits of Principles of Biochemistry and CHEM 358 or 360, or permission of instructor. Offered alternate years. Lecs, T R 9:05. M. N. Kazarinoff, N. Noy, P. Stover.

Molecular mechanisms by which sensory, hormonal, and nutritional inputs cause changes in enzyme activity in order to regulate metabolic transformations. Emphasis is on gene expression, protein modification,

and allosteric effects using examples from mammalian systems. Consideration of identification and characterization of regulatory steps in metabolism from both theoretical and practical aspects.

[BIOBM 636 Cell Biology
Spring. 2 credits. Prerequisites: BIOBM 330 or 333 or 331 and 332, and 432, or their equivalents. Not offered 1996–97. Lec, T 9:05–11:00. A. P. Bretscher.
Lectures covering current topics in cell biology, including a detailed discussion of secretion, endocytosis, membrane-bound organelles, membrane recycling, the cytoskeleton, cell motility, junctions, the cell cycle, and related topics. Together with BIOBM 632 and 639, this course provides broad coverage of the cell biology subject area.]

BIOBM 637 Integration and Coordination of Energy Metabolism (also Nutritional Sciences 636)
Fall. 3 credits. Prerequisite: BIOBM 330 or 331 or 333 or equivalent. Lecs, M W F 9:05. Evening prelims to be arranged. W. J. Arion.
The elements and dynamics of energy metabolism in humans and higher animals are developed systematically through biochemical characterizations of the metabolic components and structure of major tissues and organs. Emphasis is placed on correlations with physiologic functions. Mechanisms that control energy metabolism within individual tissues and coordinate these processes *in vivo* are analyzed in the contexts of selected physiologic and pathologic stresses.

BIOBM 639 The Nucleus
Spring. 2 credits. Prerequisite: BIOBM 330 or 333 or 331 and 332 or equivalent. Recommended: BIOGD 281. Lec, M 7:30–9:25 p.m. J. T. Lis.
Lectures on topics of eucaryotic gene organization, regulation of gene expression, RNA processing, chromatin structure, the structure and movement of chromosomes, and the architecture of the nucleus. This course covers the structure and function of the nucleus at the molecular and cell biological levels, and together with BIOBM 632 and 636, provides broad coverage of the cell biology subject area.

BIOBM 648 Plant Biochemistry (BIOPL 648)
Spring. 3 credits. Prerequisites: BIOBM 330 or 333 or 331 and 332, organic chemistry, and a course in plant physiology. Offered alternate years. Lecs, M W F 9:05. A. T. Jagendorf and staff.
For course description, see BIOPL 648.

BIOBM 692 Protein-Nucleic Acid Interactions (BIOMI 692)
Spring. 3 credits. Prerequisites: BIOBM 330 or 333 or 331 and 332 and 633. Lecs, T R 10:10–11:25. J. D. Helmann.
For course description, see BIOMI 692.

BIOBM 732–737 Current Topics in Biochemistry
Fall or spring. 1/2 or 1 credit for each topic. May be repeated for credit. Prerequisite: BIOBM 330 or 333 or 331 and 332 or equivalent. S-U grades only.
Lectures and seminars on specialized topics. Topics for fall and spring to be announced in the division's course supplement published at the beginning of each semester.

BIOBM 738 Macromolecular Crystallography (also Chemistry 788)
Spring. 3 credits. S-U grades optional. Prerequisite: permission of instructor. Offered alternate years. Lecs, M W F 10:10. S. A. Ealick, P. A. Karplus, J. C. Clardy.
Lectures briefly cover the fundamentals of crystallography and focus on methods for determining the 3-dimensional structures of macromolecules. These include crystallization, data collection, multiple isomorphous replacement, molecular replacement, model building, refinement, and structure interpretation.

[BIOBM 750 Cancer Cell Biology (also Veterinary Pathology 750)
Spring. 3 credits. Prerequisite: BIOBM 330 or 333 or 331 and 332 or equivalent. Offered alternate years. Not offered 1996–97. Lecs to be arranged. J. Guan, R. Levine, B. Pauli, A. Yen.
Course covers molecular, cellular and genetic aspects of cancer. The course is divided into three sections: The first section addresses tumor etiology, progression and metastasis; the second section looks at cell-matrix and cell-cell interactions in cancer; and, the third section focuses on cell cycle. For a detailed course description, see the Division of Biological Sciences "Course Supplement."]

BIOBM 751 Ethical Issues and Professional Responsibilities (also Toxicology 751 and Science and Technology Studies 751)
Fall or spring. 2 credits. Limited to graduate students beyond first year. S-U grades only. Fall: sem, T R 2:30–4:15 (7 weeks, Oct. 22-Dec. 5); spring: sem, W 2:30–4:15. Additional sections may be offered. J. M. Fessenden MacDonald.
Ethical issues in research and the professional responsibilities of scientists are discussed in a case-study format. Topics to be discussed include regulations; data selection, manipulation, and representation; fraud, misconduct, and whistle-blowing; conflicts of interest and commitment; authorship, ownership, and intellectual properties; peer review and confidentiality; scientific response to external pressure; legal liabilities; and professional codes of ethics.

BIOBM 830 Biochemistry Seminar
Fall or spring. No credit. Sem, F 4:00. Staff.
Lectures on current research in biochemistry, presented by distinguished visitors and staff members. Lectures are open to everyone, but registration limited to graduate students in Biochemistry, Molecular and Cell Biology.

BIOBM 831 Advanced Biochemical Methods I
Fall. 6 credits. Limited to graduate students majoring in biochemistry. S-U grades optional. Labs and discs, 12 hours each week to be arranged. Organizational meeting first R of semester, 10:10. B. M. Tyler and staff.
This course emphasizes experimental design and the concepts implicit in current approaches to research in biochemistry and cell biology. Students are required to read papers and participate actively in discussions in order to design their own protocols before performing experiments using the techniques most common in the recent literature of these fields.

BIOBM 832 Advanced Biochemical Methods II
Spring. 6 credits. Limited to graduate students majoring in biochemistry. S-U grades only. Lab to be arranged. Staff (Coordinator: G. W. Feigenson, graduate faculty representative).
Research in the laboratories of two or three different professors chosen by the student. Arrangements are made jointly between the graduate field representative and the research adviser.

BIOBM 833 Research Seminar in Biochemistry
Fall or spring. 1 credit each term. May be repeated for credit. Required of, and limited to, second-, third-, and fourth-year graduate students majoring in biochemistry. S-U grades only. Sem, M 12:20–1:30. T. C. Huffaker, W. J. Brown, J. T. Lis.
Each student presents one seminar per year on his or her thesis research and then meets with instructors and thesis committee members for evaluation.

BIOBM 835–836 Methods and Logic in Biochemistry, Molecular and Cell Biology
835, fall; 836, spring. 1 credit each term. Limited to first-year graduate students majoring in the Field of Biochemistry, Molecular and Cell Biology. S-U grades only. Sem and disc to be arranged. Fall: S. E. Ealick, G. P. Hess; spring: Staff.
A seminar course with critical discussion by students of original research papers. A variety of topics in biochemistry, molecular and cell biology are covered.

Related Courses in Other Departments

Lipids (Biological Sciences [BIOAP] 619 and Nutritional Sciences 602)

Molecular Aspects of Development (Biological Sciences [BIOGD] 483)

Molecular Mechanisms of Hormone Action (Biological Sciences [BIOAP] 658 and Veterinary Medicine 758)

Teaching Experience (Biological Sciences [BIO G] 498)

Undergraduate Research in Biology (Biological Sciences [BIO G] 499)

ECOLOGY AND EVOLUTIONARY BIOLOGY (BIOES)

BIOES 154 The Sea: An Introduction to Oceanography (also Geological Sciences 104)
Spring. 3 or 4 credits (4-credit option includes one 2 1/2 hour laboratory each week). S-U grades optional. Lecs, M W 8:40–9:55; labs, M W or F 2:00–4:25, or M 7:30–9:55 p.m.. C. H. Greene, W. M. White.
A survey of the physics, chemistry, geology, and biology of the oceans for both science and non-science majors. Topics include: seafloor spreading and plate tectonics, marine sedimentation, chemistry of seawater, ocean currents and circulation, the oceans and climate, ocean ecology, coastal processes, marine pollution, and marine resources.

BIOES 261 Ecology and the Environment
Fall or summer. 4 credits. Prerequisite: one year of introductory biology. S-U grades optional. Lecs, M W F 11:15; disc, W or R 1:25, 2:30, or 3:35. T. E. Dawson, R. B. Root.
An introduction to principles of ecology concerning the interactions between organisms and their environment. The course covers both terrestrial and aquatic ecology, drawing examples from both plant and animal studies. Phenomena that occur at the individual, population, community, and ecosystem levels of organization are discussed. Ecological principles are extensively applied to current environmental problems and issues.

BIOES 263 Field Ecology
Fall. 2 credits. Limited to 25 students. Prerequisite: concurrent or previous enrollment in BIOES 261. Lec, R 1:25; lab, F 12:20–5:00. One weekend field trip to the Hudson Valley. Small fee for field trip. R. B. Root.
Field exercises designed to give students direct experience with field work, with emphasis on developing observational skills, journal keeping, and a landscape perspective. Topics include plant succession, niche relationships of insects, influence of herbivores and competition on plant performance, decomposition of soil litter, sampling plankton, and use of scientific collections.

BIOES 264 Birds in Biology, Lectures
Spring. 2 credits. May not be taken for credit after BIOES 475. Intended for students with no background in biology. S-U grades optional. Lecs, M W 9:05. A. A. Dhondt.
Using birds as a starting point, this course aims at bringing exciting new insights in bird biology to non-majors. Bird research has often generated new insights in the biological sciences. Starting from studies on birds a number of topics from a variety of biological disciplines can be addressed. These include problems from behavioral ecology (mating systems, sperm competition, extra-pair paternity, territorial behavior, song), from population ecology (population dynamics, micro-evolution, competition), from evolutionary biology (trade-offs in life history theory, optimal clutch size) and from conservation biology (biodiversity, habitat fragmentation, inbreeding).

BIOES 266 Birds in Biology, Laboratory
Spring. 1 credit. Limited to 40 students. Intended for students with no background in biology. Prerequisite: concurrent enrollment in BIOES 264. S-U grades optional. Lab, S 9:05–12:05; some all-day field trips to be arranged. Carpooling to the Vertebrate Collections at Research Park is necessary several times during the semester. A. A. Dhondt.
Laboratories supplement the lecture course and provide hands-on experience. Laboratories include field trips, some field-research experience, and work in the Cornell bird collections.

[BIOES 272 Functional Ecology of Vertebrates
Spring. 4 credits. Enrollment limited to 60 students (15 per laboratory section); preference given to sophomores and juniors. Prerequisite: one year of introductory biology for majors. Offered alternate years. Not offered 1996–97; next offered spring 1998. Lecs, M W F 9:05; lab, M T W or R 1:25–4:25. Fee, $15. Staff.
An introductory course for students interested in organismal biology. The features of the physical environment that are important to insects and vertebrates are used to illustrate the interaction of physiological, behavioral, and morphological characteristics in organismal activity and homeostasis. Laboratories include a survey of the diversity of endothermal and ectothermal animals, ecophysiological measurements, and measurements of important environmental parameters in local habitats. This course uses live and preserved vertebrate animals for field observations and laboratory exercises.]

BIOES 274 The Vertebrates: Structure, Function, and Evolution
Spring. 4 credits. Prerequisite: one year of introductory biology. Offered alternate years. Lecs, M W F 12:20; labs, M T or W 1:25–4:25. Evening prelims to be announced. Fee, $15. Staff.
An exploration of the relations between form and function in biological systems with an emphasis on trends in vertebrate evolution. Lectures integrate data from topics such as locomotion, feeding, size, and scaling with issues of historical importance and current interest (e.g., correlation of body parts, adaptationist explanations, developmental constraints, criteria for determining biomechanical and energetic "efficiency"). Laboratories include dissections of preserved vertebrate animals and noninvasive live animal demonstrations (motion analysis, surface electrode, and force-plate recordings).

BIOES 275 Human Biology and Evolution (also Anthropology 275 and Nutritional Sciences 275)
Fall. 3 credits. S-U grades optional, with permission of either instructor. Offered alternate years. Lecs, W F 10:10; disc, M 10:10. K. A. R. Kennedy, J. D. Haas.
An introduction to the biology of *Homo sapiens* through an examination of human evolution, biological diversity, and modes of adaptation to past and present environments. Evolutionary theory is reviewed in relation to the current evidence from the fossil record and studies of the evolution of human behavior. A survey of human adaptation covers a complex of biological and behavioral responses to environmental stress. Human diversity is examined as the product of long-term evolutionary forces and short-term adaptive responses. Topics such as creationism, the Piltdown fraud, the sociobiology debate, genetic engineering, race and IQ, and racism are presented as examples of current issues in human biology.

BIOES 278 Evolutionary Biology
Fall or spring. 3 or 4 credits. (4-credit option involves writing component and two discussion sections per week; limited to 20 students each semester. Students may not preregister for the 4-credit option; interested students complete an application form on the first day of class.) Limited to 300 students; not open to freshmen fall semester. Prerequisite: one year introductory biology or permission of instructor. S-U grades optional. Lecs, T R 9:05; disc, 1 hour each week to be arranged. Evening prelims: Fall, Oct. 1 and Nov. 5; spring, Feb. 25 and Apr. 1. Fall, A. S. Kondroshov; spring, R. G. Harrison and staff.
The course considers explanations for patterns of diversity and for the apparent "good fit" of organisms to the environment. Topics covered include the genetic and developmental basis of evolutionary change, processes at the population level, the theory of evolution by natural selection, levels of selection, concepts of fitness and adaptation, modes of speciation, long-term trends in evolution, rates of evolution, and extinction. Students taking the 4-credit option read additional materials from the primary literature and write a series of essays in place of the regular prelims.

[BIOES 371 Human Paleontology (also Anthropology 371)
Fall. 4 credits. Prerequisite: one year of introductory biology or ANTHR 101 or permission of instructor. Offered alternate years. Not offered 1996–97; next offered fall 1997. Lecs, M W F 2:30; lab, 1 hour each week to be arranged; occasional field trips. K. A. R. Kennedy.
A broad survey of the fossil evidence for human evolution with special attention to skeletal and dental anatomy, geological contexts, paleoecology, dating methods, archaeological associations, and current theories of human origins and physical diversity.]

[BIOES 373 Biology of the Marine Invertebrates
Fall. 4 credits. Limited to 30 students. Prerequisite: one year of introductory biology for majors. Offered alternate years. Not offered 1996–97. Lecs, M W F 10:10; lab, W 1:25–4:25; 1 optional weekend field trip to Shoals Marine Laboratory. $60 fee for optional field trip. C. D. Harvell.
An introduction to the biology and evolution of the major invertebrate phyla, concentrating on marine representatives. In addition to the evolution of form and function, lectures cover aspects of ecology, behavior, physiology, chemical ecology, and natural history of invertebrates. The Shoals field trip is an excellent opportunity to study representatives of most of the major phyla in their natural habitat. Laboratory demonstrations on campus involve live marine and freshwater invertebrates.]

BIOES 452 Herbivores and Plants: Chemical Ecology and Coevolution (also Entomology 452)
Spring. 3 credits. Prerequisites: one year of introductory biology, BIOES 261, CHEM 253 or 357/358 and 251 or 301, or permission of instructor. S-U grades optional. Offered alternate years. Lecs, M W F 11:15. Field trips, additional lectures, or laboratory demonstrations may be held in place of F lecture. P. P. Feeny.
Topics include significance of plant chemistry in mediating interactions between plants and herbivorous animals; mechanisms and strategies of plant finding and exploitation by animals, especially insects, and of defense and escape by plants; evolutionary hypotheses for ecological patterns of resistance and attack; and implications for human food and agriculture.

[BIOES 455 Insect Ecology (also Entomology 455)
Fall. 3 credits. Prerequisites: BIOES 261 or equivalent and ENTOM 212 or knowledge of another taxon. S-U grades optional. Offered alternate years. Not offered 1996–97. Lecs, M W F 11:15. R. B. Root.
Topics include the nature and consequences of biotic diversity, biogeography, coevolution, adaptive syndromes exhibited by various guilds, population regulation, impact of insects on ecosystems, comparative and functional analysis of communities, and differences in the organization of natural and managed systems. Ecological and evolutionary principles are integrated by thorough study of exemplars.]

BIOES 456 Stream Ecology (also Entomology 456)
Spring. 4 credits. Recommended: BIOES 261. S-U grades optional, with permission of instructor. Offered alternate years. Lecs, T R 9:05; labs, T W or R 1:25–4:25. Field project with term paper. B. L. Peckarsky, M. B. Bain.
Lecture addresses the patterns and processes occurring in stream ecosystems, including channel formation; water chemistry; watershed influences; plant, invertebrate, and fish community structure; nutrient cycling; trophic dynamics, colonization and succession; community dynamics; conservation; and the impacts of disturbances. **Lab:** A field project includes descriptive and experimental techniques and hypotheses testing related environmental assessment.

BIOES 457 Limnology: Ecology of Lakes, Lectures
Fall. 3 credits. Prerequisite: BIOES 261 or written permission of instructor. Recommended: introductory chemistry. Offered alternate years. Lecs, M W F 11:15. N. G. Hairston, Jr.
The study of continental waters, with emphasis on lakes and ponds. Factors regulating nutrient cycling processes, population and community dynamics of freshwater organisms, and physical and chemical properties of fresh water are considered.

BIOES 459 Limnology: Ecology of Lakes, Laboratory
Fall. 2 credits. Prerequisite: concurrent or previous enrollment in BIOES 457. Offered alternate years. Lab, T W or R 1:25–4:25; 1 weekend field trip. Fee, $10. N. G. Hairston, Jr. and staff.
Laboratories and field trips devoted to studies of the biological, chemical, and physical properties of lakes and other freshwater environments. Vertebrate dissection (fish) during one laboratory exercise and during a portion of weekend field trip.

BIOES 461 Population and Evolutionary Ecology
Spring. 4 credits. Prerequisites: BIOES 261 or 278 plus two semesters of calculus, or permission of instructor. S-U grades optional. Offered alternate years. Lecs, M W F 9:05; lab, M or T 1:25–4:25. D. W. Winkler, A. S. Kondrashov.
Problems of ecology are viewed from an evolutionary perspective, exploring issues of adaptation and fitness by developing advanced understanding of demography and interspecific interactions. Blending theory and empirical findings, the course explores population dynamics; life-history theory; dispersal; competition; predation; parasite-host coevolution; mutualisms; and sexual, kin, and group selection. Methods of estimation and analysis are learned in laboratory.

BIOES 462 Marine Ecology
Spring. 3 credits. Limited to 75 students. Prerequisite: BIOES 261. Offered alternate years. Lecs and disc, M W F 10:10. C. D. Harvell, C. H. Greene.
Lectures and discussion focus on current research in broad areas of marine ecology with an emphasis on processes unique to marine systems. A synthetic treatment of multiple levels of organization in marine systems including organismal, population, community, ecosystems, and evolutionary biology. Examples are drawn from all types of marine habitats, including polar seas, temperate coastal waters, and tropical coral reefs.

BIOES 463 Plant Ecology and Population Biology, Lectures
Fall. 3 credits. Prerequisite: BIOES 261 or 278 or equivalents, or permission of instructor. Recommended: some taxonomic familiarity with vascular plants and concurrent enrollment in BIOES 465. Offered alternate years. Lecs, M W F 11:15. M. A. Geber, P. L. Marks.
This course examines the biological and historical factors affecting the structure of plant communities, and the distribution, abundance, and population dynamics of individual species. The influence of the environment, disturbance history, competition, and herbivory on the organization of plant communities are considered. Plant populations are also studied through an analysis of plant life histories and plant-plant and plant-animal interactions. Throughout the course an attempt is made to blend empirical patterns, experimental results, and theory. Readings are drawn from the primary literature.

[BIOES 464 Macroevolution
Spring. 4 credits. Limited to 25 students. Prerequisite: BIOES 278 or permission of instructor. S-U grades optional, with permission of instructor. Offered alternate years. Not offered 1996–97. Lecs, T R 10:10–11:25; disc, 1 hour each week to be arranged. A. R. McCune.
An advanced course in evolutionary biology centered on large-scale features of evolution. Areas of emphasis include patterns and processes of speciation, phylogeny reconstruction, the origins and fate of variation, causes of major evolutionary transitions, and patterns of diversification and extinction in the fossil record. Discussion of these problems involve data and approaches from genetics, morphology, systematics, paleobiology, development, and ecology.]

BIOES 465 Plant Ecology and Population Biology, Laboratory
Fall. 1 credit. Prerequisite: concurrent enrollment in BIOES 463. Offered alternate years. Lab, F 12:05–5:00. M. A. Geber, P. L. Marks.
Laboratory and field exercises designed to give firsthand experience with the ecology and population biology of plants. Emphasis is on making observations and measurements of plants in the field and greenhouse, and on data analysis.

[BIOES 466 Physiological Plant Ecology, Lectures
Spring. 3 credits. Limited to 35 students. Prerequisite: BIOES 261 or introductory plant physiology. S-U grades optional, with permission of instructor. Offered alternate years. Not offered 1996–97. Lecs, T R 10:10–11:25; optional disc to be arranged. T. E. Dawson.
A detailed survey of the physiological approaches used to understand the relationships between plants and their environment. Lectures explore physiological adaptation; limiting factors; resource acquisition and allocation; photosynthesis, carbon, and energy balance; water use and water relations; nutrient relations; linking physiology, development, and morphology; stress physiology; life history and physiology; the evolution of physiological performance; and physiology at the population and community and ecosystem levels. Readings draw from the primary literature and textbooks.]

[BIOES 468 Physiological Plant Ecology, Laboratory
Spring. 2 credits. Limited to 15 students. Prerequisite: previous or concurrent enrollment in BIOES 466. Offered alternate years. Not offered 1996–97. Lab, T 1:25–4:25, plus additional lab hours to be arranged. T. E. Dawson.
A detailed survey of the physiological approaches used in understanding the relationships between plants and their environment. Laboratories apply physiological techniques to specific ecological problems and cover aspects of experimental design and computer-aided data analysis. Most laboratories run past the three-hour period, with students spending an average of 3 hours/week in additional lab time for this course.]

BIOES 470 Ecological Genetics (also Entomology 470)
Spring. 4 credits. Prerequisite: BIOES 278 or permission of instructor. S-U grades optional. Offered alternate years. Lecs, T R 10:10–11:25; disc, 1 hour each week to be arranged. S. Via.
A study of the relationships between genetic and ecological processes in populations. Topics include consequences of genetic variation in age-structured populations; demographic concepts of fitness; evaluation of methods for measuring genetic variation and natural selection on ecologically important traits; genetics of competitive ability and predator avoidance; genetic and ecological aspects of phenotypic plasticity; character displacement; maintenance of genetic variability; limits to selection. How theory can be used to formulate hypotheses about evolutionary mechanisms in natural populations is considered and experiments designed to test such hypotheses are evaluated.

[BIOES 471 Mammalogy
Fall. 4 credits. Recommended: BIOES 274. S-U grades optional, with permission of instructor. Offered alternate years. Not offered 1996–97. Lecs, M W F 12:20; lab, M T or W 1:25–4:25; 1 weekend field trip required. Carpooling to the Vertebrate Collections at Research Park is necessary several times during the semester. Fee, $15. Staff.
Lectures on the evolution, classification, distribution, and adaptations of mammals. Laboratory and fieldwork on systematics, ecology, and natural history of mammals of the world, with primary emphasis on the

North American fauna. Systematics laboratories held in the museum at Research Park. Live animals are studied in the field and are sometimes used in the laboratory for nondestructive demonstrations or experiments. The systematics laboratory exercises are based on museum specimens.]

[BIOES 472 Herpetology

Spring. 4 credits. Recommended: BIOES 274. S-U grades optional, with permission of instructor. Offered alternate years. Not offered 1996–97. Lecs, T R 12:20; labs, M W or T R 1:25–4:25; occasional field trips and special projects. Fee, $15. Staff.

Lectures cover various aspects of the biology of amphibians and reptiles, including evolution, zoogeography, ecology, behavior, and physiology. Laboratory includes systematics, functional morphology, and behavior. Live animals are studied in the field and are used in the laboratory for nondestructive demonstrations and experiments. The systematics laboratory exercises are based on museum specimens and dissection of preserved materials.]

BIOES 473 Ecology of Agricultural Systems (also Soil, Crop, and Atmospheric Sciences 473)

Fall. 3 credits. Limited to 45 students. Prerequisite: BIOES 261 or permission of instructor. S-U grades optional. Offered alternate years. Lecs and discs, T R 2:30–3:45. During the first 6 weeks of class, the Thursday meetings may run to 5:00 because of field trips. A. G. Power and staff.

Analysis of the ecological processes operating in agricultural systems, with an emphasis on the interactions between organisms. Topics include nutrient dynamics in agroecosystems, plant competition and facilitation, intercropping, the ecology of species invasions, mutualism in agroecosystems, plant-herbivore relations, plant-pathogen interactions, biological pest control, and evolutionary processes in agriculture. Case studies from both the tropics and the temperate zone are used to illustrate important concepts.

BIOES 474 Laboratory and Field Methods in Human Biology (also Anthropology 474)

Spring. 5 credits. Limited to 16 students with permission of instructor obtained by preregistering in E231 Corson. Prerequisite: one year of introductory biology or ANTHR 101 or permission of instructor. Offered alternate years. Lecs and labs, T R 10:10–12:05; additional hours to be arranged. Independent research project required. K. A. R. Kennedy.

Practical exercises and demonstrations of modern approaches to the methodology of physical anthropology. Emphasis on comparative human anatomy, osteology, description of skeletal and living subjects, paleopathology, skeletal maturation, and relevant field techniques for the archaeologist and forensic anthropologist. There is a dissection of a profused (dead) nonhuman primate, usually a macaque or baboon. Students attend demonstrations of the dissection prepared by the prosector (a hired graduate student).

BIOES 475 Ornithology

Fall. 4 credits. Limited to 30 students, with permission of instructor obtained by preregistering in E241 Corson. Recommended: BIOES 274. S-U grades optional, with permission of instructor. Offered alternate years. Lecs and labs, T R 12:20–4:25; occasional field trips and special projects. Carpooling to the Vertebrate Collections at Research Park is necessary once a week. Fee, $15. D. W. Winkler.

Lectures cover various aspects of the biology of birds, including anatomy, physiology, systematics, evolution, behavior, ecology, and biogeography. Laboratory includes dissection of dead material, studies of skeletons and plumages, and specimen identification of avian families of the world and species of New York. Independent projects emphasize research skills.

BIOES 476 Biology of Fishes

Fall. 4 credits. Limited to 24 students. Recommended: BIOES 272 or 274 or equivalent experience in vertebrate zoology. S-U grades optional, with permission of instructor. Offered alternate years. Lecs, M W F 10:10; lab, M 1:25–4:25. A small lab fee may be required. A. R. McCune.

An introduction to the study of fishes: their structure, evolution, distribution, ecology, physiology, behavior, classification, and identification, with emphasis on local species. Live animals are studied in the field and are sometimes used in the laboratory for nondestructive demonstrations or experiments. The systematics and dissection laboratories use preserved specimens.

BIOES 478 Ecosystem Biology

Spring. 4 credits. Prerequisite: BIOES 261 or equivalent. S-U grades optional. Offered alternate years. Lecs and discs, T R 10:10–12:05. L. O. Hedin, R. W. Howarth.

Analysis of ecosystems in terms of energy flow and nutrient cycles, emphasizing an experimental approach and comparative aspects of terrestrial, freshwater, and marine ecosystems. Consideration of anthropogenic effects on ecosystems, such as from acid precipitation and offshore oil pollution. Analysis of climate change and regional environmental change from an ecosystem perspective.

[BIOES 479 Paleobiology (also Geological Sciences 479)

Fall. 3 credits. Prerequisites: one year of introductory biology for majors and either BIOES 272 or 274, GEOL 375, BIOES 373, or permission of instructor. Offered alternate years. Not offered 1996–97. Lecs, M W F 12:20. J. L. Cisne and staff.

A survey of the major groups of organisms and their evolutionary histories. Intended to fill out the biological backgrounds of geology students and the geological backgrounds of biology students concerning the nature and significance of the fossil record for their respective studies.]

BIOES 660 Field Studies in Ecology and Systematics

Fall or spring. Variable credit. Prerequisites: BIOES 261, a taxon-oriented course, and permission of instructor. Estimated costs: to be announced. S-U grades optional, with permission of instructor. Lecs and field trips to be arranged. Staff.

This course provides students with opportunities to learn field techniques and a new biotas by participating in an intensive series of field exercises. Extended field trips may be scheduled during fall break, intersession, or spring break. The regions visited, trip objectives, and other details are announced by the various instructors in the Division's "Course Supplement" issued at the beginning of the semester. Meetings on campus are devoted to orientation and reports on completed projects.

Section 01: Life Histories of Marine and Freshwater Invertebrates

Fall. 2 credits. Prerequisite: Undergraduates must have previous experience or course work with marine or freshwater invertebrates. Fee: $100 (to help cover transporation and housing at Shoals Marine Lab). Two extended weekend field trips in early September and October. Organizational meeting Thursday, August 29, 4:00 p.m., in Corson/Mudd A409. C. D. Harvell, N. G. Hairston, Jr.

Field trips to the Shoals Marine Lab and Shackelton Point Field Station. Students employ experimental approaches to study the evolution of invertebrate life histories.

BIOES 661 Environmental Policy (also ALS 661 and Biology and Society 461)

Fall and spring. 3 credits each term. (Students must register for 6 credits each term, since an "R" grade is given at the end of the fall term.) Limited to 12 students. Prerequisite: permission of instructor. Sem, R 2:30–4:30. D. Pimentel.

This course uses an interdisciplinary approach to focus on complex environmental problems. Ten to twelve students, representing several disciplines, investigate significant environmental problems. The research team spends two semesters preparing a scientific report for publication in *Science* or *BioScience*.

[BIOES 662 Mathematical Ecology (also Statistics and Biometry 662)

Spring. 3 credits. Prerequisites: one year of calculus and a course in statistics. Recommended: a general ecology course. S-U grades optional, with permission of instructor. Offered alternate years. Not offered 1996–97. Lecs, M W F 12:20. C. Castillo-Chavez and staff.

Mathematical and statistical analysis of populations and communities: theory and methods. Spatial and temporal pattern analysis. Deterministic and stochastic models of population dynamics. Model formulation, parameter estimation, simulation, and analytical techniques.]

[BIOES 663 Theoretical Population Genetics

Spring. 3 credits. Prerequisites: knowledge of basic population genetics (e.g., BIOGD 481), and some matnematics (e.g., MATH 111). Primarily for graduate students; permission of instructor required for undergraduates. S-U grades optional. Offered alternate years. Not offered 1996–97. Lec, 2 hours each week to be arranged; lab (computer), 3 hours each week to be arranged. A. S. Kondrashov.

Theoretical population genetics (TPG) is one of the areas of current evolutionary biology. The course explains why TPG is successful in its domain and what its limitations are. Students analyze the effects of seven elementary factors of population dynamics (mutation, selection, drift, migration, segregation, recombination, and non-random mating). Consideration of biologically relevant situations when several factors act simultaneously (migration-drift, mutation-selection-drift, segregation-recombination-

selection, etc.) leads to studying the changes of not only the population state, but of the "rules of the game" themselves (evolution of reproductive isolation, life history, recombination, mutability, etc.). Students study in detail several topics of general biological interest (maintenance of quantitative variability, evolution of aging, and sexual selection). Active use of computers in analyzing the models, but no formal training in programming required.]

[BIOES 665 Limnology Seminar
Spring. 1 credit. May be repeated for credit. Primarily for graduate students; written permission of instructor required for undergraduates. S-U grades optional. Offered alternate years. Not offered 1996–97. Sem to be arranged. N. G. Hairston, Jr.
A seminar course on advanced topics in freshwater ecology.]

[BIOES 668 Principles of Biogeochemistry
Spring. 4 credits. Limited to 20 students. Prerequisite: solid background in ecology, environmental chemistry, or related environmental science. Permission of instructor required for undergraduates. S-U grades optional. Offered alternate years. Not offered 1996–97. Lecs and discs, T R 10:10–12:05. R. W. Howarth, L. O. Hedin.
Lectures cover the biotic controls on the chemistry of the environment and the chemical control of ecosystem function. Emphasis is on cycles of major elements and minor elements globally and in selected ecosystems, stressing the coupling of element cycles. A comparative approach is used to illustrate similarities and differences in element cycling among ecosystems. Analysis of both theoretical and applied issues, including global atmospheric changes and factors controlling the acidification of lakes and soils.]

BIOES 669 Plant Ecology Seminar
Spring. 1 credit. May be repeated for credit. Suggested for students majoring or minoring in plant ecology. S-U grades optional. Sem to be arranged. Staff.
Includes review of current literature, student research, and selected topics of interest to participants.

BIOES 670 Graduate Seminar in Vertebrate Biology
Fall or spring. 1 credit. May be repeated for credit. Primarily for graduate students; written permission of instructor required for undergraduates. S-U grades only. Sem to be arranged. Staff.
Seminar presentations and discussions by students on areas of current research in vertebrate biology. Topics vary from semester to semester.

[BIOES 672 Graduate Seminar in Physiological Ecology
Spring. 2 credits. May be repeated for credit. Limited to 12 students. Prerequisite: a course in plant or animal physiology, especially BIOES 466 or 467. Permission required for undergraduates. S-U grades only. Offered alternate years. Not offered 1996–97. Sem, 2 hours each week to be arranged. T. E. Dawson and staff.
Discussion of topics on water balance, energetics, and temperature regulation emphasize parallels and contrasts in the relations of animals and plants to their biophysical environments. Each student leads a discussion and prepares a written review of a topic, drawing on the primary literature of his or her own research interests.]

[BIOES 673 Human Evolution: Concepts, History, and Theory (also Anthropology 673)
Fall. 3 credits. Prerequisite: one year of introductory biology, ANTHR 101, or permission of instructor. Offered alternate years. Not offered 1996–97; next offered fall 1998. Lec, M 2:30; sem and disc, W 7:30–9:30 p.m. K. A. R. Kennedy.
The historical background of present-day concepts of man's evolutionary variations and adaptations in space and time is surveyed. The formation of biological anthropology as an area of scientific inquiry within the social and biological sciences is reviewed. Students select their own topics within a broad range of readings in the history of Western concepts of human origins, diversity, and place in nature.]

BIOES 760 Special Topics in Evolution and Ecology
Fall or spring. 1–3 credits. May be repeated for credit. Enrollment limited. S-U grades optional, with permission of instructor. Hours to be arranged. Staff.
Independent or group intensive study of special topics of current interest. Content varies and is arranged between student and staff member.

BIOES 767 Current Topics in Ecology and Evolutionary Biology
Fall. 4 credits. Prerequisite: permission of instructor required for undergraduates. S-U grades only. Lecs and discs, T R 8–9:55. One weekend field trip. Staff.
Critical evaluation and discussion of theory and research in ecology and evolutionary biology. Lectures by faculty and student-led discussions of topics in areas of current importance.

Related Courses in Other Departments

Advanced Soil Microbiology (Soil, Crop, and Atmospheric Sciences 666)

Animal Social Behavior (Biological Sciences [BIONB] 427)

Early People: The Archaeological and Fossil Record (Anthropology 203 and Archaeology 203)

Evolution of the Earth and Life (Biological Sciences [BIO G] 170 and Geological Sciences 102)

Marine Sciences Courses (Biological Sciences [BIOSM] 363–370, 477)

Related Courses in Entomology (Entomology 212, 331, 332, 370, 453, 471, 631, 634, 672)

Related Courses in Natural Resources (Natural Resources 270, 302)

Taxonomy of Vascular Plants (Biological Sciences [BIOPL] 248)

Teaching Experience (Biological Sciences [BIO G] 498)

Undergraduate Research in Biology (Biological Sciences [BIO G] 499)

Undergraduate Seminar in Biology (Biological Sciences [BIO G] 400)

GENETICS AND DEVELOPMENT (BIOGD)

BIOGD 184 Understanding Genetics
Spring. 3 credits. May not be taken for credit after BIOGD 281 or 282. This course may be used toward the science distribution requirement of the College of Arts and Sciences and the Group B distribution requirement of the College of Agriculture and Life Sciences. This course may not be used to fulfill the requirements for any Program of Study in the biological sciences major. S-U grades optional. Offered alternate years. Lecs, M W F 9:05. T. D. Fox.
An introduction to genetics for students majoring in fields other than biology. Genetics is a rapidly developing science that is providing insight into all aspects of biology and practical tools which increasingly affect our lives. The course shows how major conclusions about inheritance have been derived from the experimental evidence, drawing on examples from the biology of humans, other animals, plants, fungi, and bacteria. It also illustrates current and future applications of genetic discoveries. For example, the basic principles of inheritance, in conjunction with methods for the isolation and detection of specific gene fragments, is used to understand the detection of genetic diseases and the identification of individuals (DNA fingerprinting). Other topics to be covered include the origin of mutations, use of genetic methods to alter the properties of organisms and the influence of inheritance on behavior.

BIOGD 281 Genetics
Fall, spring, or summer (8-week session). 5 credits. Not open to freshmen in fall semester. Enrollment may be limited to 200 students. Prerequisite: one year of introductory biology or equivalent. No admittance after first week of classes. Lecs, T R 10:10–12:05; lab, T W or F 2:30–4:25; additional hours to be arranged. Students do not choose lab sections during course enrollment; lab assignments are made during first day of classes. Problem-solving sessions strongly recommended, T or W 8:30–9:45 (additional session to be arranged if necessary). T. D. Fox, M. L. Goldberg, R. J. MacIntyre.
A general study of the fundamental principles of genetics in eukaryotes and prokaryotes. Discussions of gene transmission, gene action and interaction, gene linkage and recombination, gene structure, gene and chromosome mutations, genes in populations, and extrachromosomal inheritance. Aspects of recombinant DNA technology are discussed. In the laboratory, students perform experiments with microorganisms and conduct an independent study of inheritance in *Drosophila*.

BIOGD 282 Human Genetics
Spring. 2 or 3 credits (2 credits if taken after BIOGD 281). Each discussion limited to 25 students. Prerequisite: one year of introductory biology or equivalent; permission of instructor required for students who have taken BIOGD 281. May not be taken for credit after BIOGD 184. S-U grades optional. Lecs, M W 10:10 (lecs, also F 10:10 1st 3 weeks only); disc, R 10:10 or F 10:10 or 11:15. R. A. Calvo.

A course designed for nonmajors. Lectures provide the technical background needed to understand controversial personal, social, and legal implications of modern genetics that are discussed in section meetings.

BIOGD 385 Developmental Biology
Fall. 3 credits. Prerequisite: BIOGD 281. Lecs, M W F 11:15. A. W. Blackler.
An introduction to the morphogenetic, cellular, and genetic aspects of the developmental biology of animals.

BIOGD 389 Embryology
Spring. 3 credits. Preference given to seniors. Prerequisites: one year of introductory biology and a knowledge of mammalian adult anatomy. Lecs, T R 10:10; labs, T or R 2–4:25. A. W. Blackler.
A course in the embryonic development of vertebrate animals, with emphasis on the comparative aspects of morphogenesis and function at the tissue and organ levels. The laboratory has a strong morphogenetic bias, emphasizing the comparative aspects of developmental anatomy and preparation for medical studies.

BIOGD 480 Seminar in Developmental Biology
Spring. 1 credit. May be repeated for credit. Limited to upperclass students. Prerequisite: BIOGD 281. S-U grades only. Sem, W 3:30–4:25. A. W. Blackler.
Topic for spring, 1997: Developmental Aspects of Sex.

BIOGD 481 Population Genetics
Fall. 4 credits. Prerequisite: BIOGD 281, BIOES 278, or equivalents. Lecs, M W F 10:10; disc, M 2:30 or T 1:25. C. F. Aquadro.
Population genetics is the study of the transmission of genetic variation through time and space. The class explores how to quantify this variation, what the distribution of variation tells us about the structure of natural populations, and about the processes that lead to evolution. Topics include the diversity and measurement of genetic variation, mating and reproductive systems, selection and fitness, genetic drift, migration and population structure, mutation, multilocus models, the genetics of speciation, quantitative traits, and the maintenance of molecular variation. Emphasis is placed on DNA sequence variation, and the interplay between theory and the data from experiments and natural populations. Specific case studies include the population genetic issues involved in DNA fingerprinting, the genetic structure and evolution of human populations, and the study of adaptation at the molecular level. Examples are drawn from studies of animals, plants, and microbes.

BIOGD 482 Human Genetics and Society
Fall. 3 credits. Enrollment limited to 24 senior biological sciences majors, with preference given to students studying genetics and development. Prerequisites: BIOGD 281 and BIOBM 330 or 333 or 331 and 332, and written permission of instructor. S-U grades optional. Disc, T 2:30–4:25 and R 2:30–3:30. R. A. Calvo, H. T. Stinson.
Presentation of some of the science and technology, plus discussion of the ethical, social, and legal implications of recent advances in human genetics. Among the topics considered are new reproductive strategies, eugenics, genetic counseling, genetic screening (prenatal, neonatal, presymptomatic, carrier, and workplace), wrongful life and wrongful birth, genetic effects of abused substances, genetics and behavior, and therapy for genetic diseases. Students lead most discussions. There is a major writing component in the course.

BIOGD 483 Molecular Aspects of Development
Spring. 3 credits. Prerequisites: BIOGD 281; BIOBM 332 (preferred) or 330 or 333; and BIOGD 385. Offered alternate years. Lecs, T R 2:30–4:00. M. F. Wolfner.
An advanced course in developmental biology, with emphasis on the molecular events underlying developmental processes. Simultaneously, a molecular biology course that focuses on how development modulates and uses transcriptional, post-transcriptional, translational and post-translational regulation of gene expression and cellular events such as cell-cell communication. Numerous developmental systems are discussed and analyzed in microorganisms, plants and, especially, animals including fruit flies, nematode worms, and vertebrates such as mice and humans. Course readings include original research articles. Discussion emphasizes specific experiments and approaches, results and their interpretation.

[BIOGD 484 Molecular Evolution
Spring. 3 credits. Prerequisites: BIOGD 281 and organic chemistry. Offered alternate years. Not offered 1996–97. Lecs, T R 11:15. R. J. MacIntyre.
An analysis of evolutionary changes in proteins and nucleic acids. Theories on the evolution of the genetic code and the construction of phylogenetic trees from biochemical data are discussed. The second half of the course concerns the evolution and the organization of genomes from viruses to higher eukaryotes.]

BIOGD 485 Bacterial Genetics (BIOMI 485)
Fall. 2 credits. Graduate students, see BIOMI 685. Prerequisite: BIOGD 281. Recommended: BIOMI 290 and BIOBM 330 or 331 and 332 or 333. Lecs, W 7:30–9:25 p.m. V. J. Stewart.
For course description, see BIOMI 485.

BIOGD 486 Advanced Eukaryotic Genetics
Spring. 4 credits. Prerequisites: BIOGD 281, BIOBM 330 or 333 or 331 and 332. S-U grades optional. Lecs, T R 12:20–2:15 (includes one-hour discussion section). E. E. Alani.
The course develops fundamental skills in eukaryotic genetic analysis through lectures and by reading, analyzing, and presenting research articles. Concepts are presented within the context of a well-studied field, such as cell cycle control or protein secretion, and then the basic tools that have been developed to study this field are used to analyze other topics such as vegetative and meiotic cell cycle control, embryonic development, chromosome organization, and protein trafficking.

BIOGD 488 Molecular Genetic Analysis
Fall or spring. 3 credits. May be repeated for credit. Limited to 10 students. Prerequisites: BIOGD 281 and written permission of instructor. Interview with instructor required (255–7816 or bjs14@cornell.edu). S-U grades optional for graduate students only. Labs, T R 1:25–4:25; additional three hours each week to be arranged. B. J. Sneath.
Course teaches the basic principles of fruit fly development and provides students with hands-on research experience in modern experimental genetic methods. The course involves screening a collection of female-sterile *Drosophila melanogaster* mutants for P-element mutations disrupting early embryonic development. The nuclei and cytoskeletal structures of mutants are characterized using fluorescence microscopy. The location of the mutated genes is examined by *in situ* hybridization. The disrupted genes are cloned and sequenced using molecular genetic techniques.

A maximum of 3 credits may be used to fulfill the requirements in the Program of Study in Genetics and Development.

[BIOGD 682 Fertilization and the Early Embryo
Spring. 2 credits. Prerequisites: BIOGD 281; BIOBM 332 (preferred), 330 or 333; and BIOGD 385. Offered alternate years. Not offered 1996–97. Lec, R 2:30–4:25. M. F. Wolfner.
This course treats the earliest events in the formation of a new organism. The methods and findings of genetic, developmental, and molecular analyses are discussed. Readings in the recent literature and discussions focus on pre-gastrulation embryos from several animal species. Topics include fertilization, pronuclear fusion, triggering mitosis, cleavage divisions, cytoplasmic determinants, changes in nuclear and cytoplasmic architecture, and midblastula transition.]

BIOGD 684 Advanced Topics in Population Genetics
Spring. 2 credits. Limited to 20 students. Prerequisites: BIOGD 481 or equivalent and written permission of instructor. S-U grades optional. Offered alternate years. Lec, T 2:30–4:25. C. F. Aquadro.
An in-depth exploration of current areas of research in population genetics. Readings primarily from recent books and the current literature. Specific topics are announced the previous fall and in the division's catalog supplement. Format includes lectures, discussion, and presentations by students.

BIOGD 685 Advanced Bacterial Genetics (BIOMI 485)
Fall. 2 credits. Limited to graduate students in Biological Sciences; see BIOMI 485. Prerequisites: BIOGD 281 or equivalent, BIOBM 330 or 331 and 332 or equivalent, and permission of instructor. Recommended: BIOMI 290 or equivalent. Lec, W 7:30–9:25; disc, R 10:10–11:00. V. J. Stewart.
For course description, see BIOMI 685.

[BIOGD 687 Developmental Genetics
Fall. 2 credits. Limited to 20 students. Prerequisites: BIOGD 281 and 385 or their equivalents. S-U grades optional. Offered alternate years. Not offered 1996–97. Lec to be arranged. K. J. Kemphues.
Selected topics focus on the use of genetic analysis in understanding mechanisms of development. Topics are drawn primarily from studies in *Drosophila*, *Caenorhabditis*, and mouse. Possible topics include pattern formation, cell lineage, neural development, maternal information in development, germ cell development, sex determination, and

intercellular communication. Students read current literature and are given the opportunity to discuss each topic in class.]

BIOGD 780 Current Topics in Genetics
Fall or spring. 2 credits. May be repeated for credit. Primarily for graduate students, with preference given to majors in the Field of Genetics; written permission of instructor required for undergraduates. Limited to 20 students. No auditors. S-U grades optional, with permission of instructor. Sem to be arranged. Fall: K. J. Kemphues; spring: D. M. Noden.
A seminar course with critical presentation and discussion by students of original research papers in a particular area of current interest. Content of the course and staff direction vary each year and are announced a semester in advance.

BIOGD 781 Problems in Genetics and Development
Fall. 2 credits. Limited to first-year graduate students in the Field of Genetics and Development. Disc to be arranged. M. F. Wolfner and staff.
An introduction to the research literature in selected areas through weekly problem sets and discussions.

BIOGD 782–783 Current Genetics/ Development Topics
Fall or spring. 1/2 or 1 credit for each topic. May be repeated for credit. S-U grades only. Lectures and seminars on specialized topics to be announced. Fall: K. J. Kemphues.

BIOGD 786 Research Seminar in Genetics and Development
Fall and spring. 1 credit. Limited to and required of second-, third-, and fourth-year graduate students in Genetics and Development. S–U grades only. Sem, W 12:20–1:30. Staff.
Each graduate student presents one seminar per year based on his or her thesis research. The student then meets with the thesis committee members for an evaluation of the presentation.

BIOGD 787 Seminar in Genetics and Development
Fall or spring. 1 credit. Limited to graduate students in Genetics and Development. S–U grades only. Sem, M 4–5:00. Staff.
Seminars in current research in genetics and developmental biology conducted by distinguished visitors and staff.

Related Courses in Other Departments

Advanced Plant Genetics (Plant Breeding 606)

Animal Development (Veterinary Anatomy 507)

Biosynthesis of Macromolecules (Biological Sciences [BIOBM] 633)

Current Topics in Biochemistry (Biological Sciences [BIOBM] 731–736)

Evolutionary Biology (Biological Sciences [BIOES] 278)

Laboratory in Molecular Biology and Genetic Engineering of Plants (Biological Sciences [BIOPL] 347)

Laboratory in Plant Molecular Biology (Biological Sciences [BIOPL] 641)

Molecular Biology and Genetic Engineering of Plants (Biological Sciences [BIOPL] 343)

Neurogenetics (Biological Sciences [BIONB] 423)

Plant Cytogenetics (Plant Breeding 446)

Plant Growth and Development (Biological Sciences [BIOPL] 644)

Plant Molecular Biology I (Biological Sciences [BIOPL] 653)

Plant Molecular Biology II (Biological Sciences [BIOPL] 652)

Protein-Nucleic Acid Interactions (Biological Sciences [BIOMI] 692)

The Nucleus (Biological Sciences [BIOBM] 639)

Undergraduate Research in Biology (Biological Sciences [BIO G] 499)

Yeast Genetics and Molecular Biology (Biological Sciences [BIOBM] 438)

MICROBIOLOGY (BIOMI)

BIOMI 192 Microorganisms on the Planet Earth
Spring. 3 credits. May not be taken for credit after BIOMI 290. S-U grades optional. Lecs, M W F 11:15. R. P. Mortlock.
A course in microbiology designed to introduce students, who have a limited background in science, to the microorganisms that populate our planet earth. Among the microorganisms studied are the bacteria, the archaebacteria, some of the single-celled plants and animals, and the viruses. Topics covered are the basic nature of microorganisms, their evolution on earth, their composition and growth, their role in the ecology of this planet, their role in human history and disease, and their use in bioengineering. This course is not a prerequisite for advanced courses in microbiology.

BIOMI 290 General Microbiology, Lectures
Fall, spring, or summer (6-week session). 2 or 3 credits (2 credits if taken after BIOMI 192). Prerequisites: one year of introductory biology for majors and one year of college chemistry, or equivalent. Recommended: concurrent registration in BIOMI 291. Lecs, M W F 11:15. M. L. Cordts, S. M. Merkel.
A comprehensive overview of the biology of microorganisms, with emphasis on bacteria. Topics include microbial cell structure and function, physiology, metabolism, genetics, diversity, and ecology. Applied aspects of microbiology are also covered such as biotechnology, the role of microorganisms in environmental processes, and immunology and medical microbiology.

BIOMI 291 General Microbiology, Laboratory
Fall or spring, 2 credits. Summer (6-week session), 2 or 3 credits. Prerequisite: concurrent or previous enrollment in BIOMI 290. Labs, M W 2–4:25, or T R 11:15–1:45 or 2–4:25. C. M. Rehkuglur.
A study of the basic principles and techniques of laboratory practice in microbiology, and fundamentals necessary for further work in the subject.

BIOMI 292 General Microbiology, Discussion
Spring. 1 credit. Prerequisite: concurrent or previous enrollment in BIOMI 290. S-U grades only. Disc to be arranged. C. M. Rehkuglar, E. Seacord.
A series of discussion groups in specialized areas of microbiology to complement BIOMI 290.

BIOMI 300 Seminar in Microbiology
Spring. 1 credit. Required of biological science students in the microbiology program of study. Strongly recommended for students considering the microbiology program of study. S-U grades only. Sem, W 12:20. Staff.
A series of lectures and seminars designed to present students with laboratory safety training and acquaint them with research projects in microbiology on the Cornell campus.

[BIOMI 304 Pathogenic Bacteriology and Mycology (also Veterinary Microbiology 318)
Spring. 2 or 4 credits (4 credits with lecture and laboratory). Limited to 40 students. Prerequisites: BIOMI 290 and 291. Strongly recommended: BIO G 305. Offered alternate years. Not offered 1996–97. Lecs, T R 1:25; labs, T R 2:25–5:00. E. Tullson.
The study of the major bacterial and fungal agents of infectious disease, with emphasis on the function of virulence mechanisms and the host-parasite interaction. Lectures cover the significance of normal flora, antibiotic therapy and drug resistance, and vaccine development. Laboratories emphasize techniques for isolation, culture, and identification of infectious agents. Animal models are used to help understand certain pathogenic mechanisms.]

BIOMI 391 Advanced Microbiology Laboratory
Fall. 3 credits. Prerequisites: BIOMI 290, 291, and BIOBM 330 or 331 or 333. Preference given to biological sciences students in the microbiology program of study. Lab, M W or T R 1:25–4:25; disc, F 1:25. J. B. Russell and staff.
A laboratory course that illustrates basic principles of experimental microbiology. The course is organized into four modules which last three weeks each: 1) ecology, 2) physiology, 3) genetics, and 4) structure and function. Students select a topic from one of the modules and conduct a two-week independent experiment at the end of the semester.

BIOMI 398 Environmental Microbiology
Spring. 3 credits. Prerequisite: BIOES 261 or BIOMI 290 or SCAS 260 or permission of instructor. Offered alternate years. Lecs, M W F 10:10. W. C. Ghiorse, E. L. Madsen.
The biology, behavior, and function of microorganisms in natural environments are discussed in relation to past and present environmental conditions on Earth. The role of microorganisms in ecologically and environmentally significant processes is also considered through discussion of specific topics such as elemental cycles, nutrient cycling, transformation of pollutant chemicals, wastewater treatment, and environmental biotechnology.

BIOMI 406 Clinical Microbiology
Fall and spring. 15 credits each semester. Prerequisite: permission of instructor. Hours to be arranged. R. P. Mortlock.
Training and practical experience in clinical microbiology in the hospital laboratory of the Cornell Medical College and New York Hospital in New York City. Emphasis is on developing students' capability in the isolation and rapid identification of organisms from various types of clinical specimens. This course is intended to prepare the student for state and federal licensing in various areas of clinical microbiology. This is a full-time program, taking place from September to August of the student's senior year.

BIOMI 408 Viruses and Disease (also Veterinary Microbiology 417)
Spring. 3 credits. Prerequisites: BIOMI 290, 291; BIO G 305; and permission of instructor. Recommended: BIOGD 281. Lecs, M W 7:30 p.m. J. Casey.
The course covers basic concepts in virology with emphasis on virus-host interactions, strategies for gene regulation, and mechanisms of pathogenicity. Selected viral infections that result in immune dysfunction and neoplasis are highlighted in the context of approaches to prevent or reduce the severity of diseases.

BIOMI 415 Bacterial Diversity
Fall. 3 credits. Prerequisites: BIOMI 290, 291, and BIOBM 330 or 331 or 333. Lecs, M W F 11:15. S. H. Zinder.
A consideration of the physiology, ecology, genetics, and practical potential of important groups of bacteria. Topics include molecular methods for determining bacterial phylogeny and taxonomy, the evolution of diverse mechanisms of energy conservation, fixation of carbon and nitrogen, and adaptation to extreme environments.

BIOMI 416 Microbial Physiology
Spring. 3 credits. Prerequisites: BIOMI 290, 291, and BIOBM 330 or 331 or 333, or their equivalents. S-U grades optional for students not specializing in the microbiology program of study. Lecs, M W F 11:15. J. P. Shapleigh.
The concern is with the physiological and metabolic functions of microorganisms. Consideration is given to chemical structure, regulation, growth, and the energy metabolism of prokaryotic organisms. Special attention is given to those aspects of microbial metabolism not normally studied in biochemistry courses.

[BIOMI 417 Medical Parasitology (also Veterinary Microbiology, Immunology and Parasitology 431)
Fall. 2 credits. Prerequisites: courses pertaining to zoology and biology. Offered alternate years. Not offered 1996–97. Lecs, T R 3:35–4:25. D. Bowman.
A systematic study of anthropod, protozoan, and helminth parasites of public health importance with emphasis on epidemiologic, clinical, and zoonotic aspects of these parasitisms.]

[BIOMI 451 Structure and Function of Bacterial Cells
Fall. 3 credits. Prerequisites: BIOMI 290 and BIOBM 330 or 331 or 333 or permission of instructor. Recommended: BIOMI 415. S-U grades optional. Offered alternate years. Not offered 1996–97. Lecs, M W F 10:10. W. C. Ghoirse.
Morphology, ultrastructure, macromolecular organization, and life cycles of bacterial cells are considered with regard to chemical composition and physiological and ecological function of cellular components.]

BIOMI 485 Bacterial Genetics (also BIOMI 685)
Fall. 2 credits. Graduate students, see BIOMI 685. Prerequisite: BIOGD 281. Recommended: BIOMI 290 and BIOBM 330 or 331 and 332 or 333. Lecs, W 7:30–9:25 p.m. V. J. Stewart.
Concepts and principles of formal genetic analysis as applied to prokaryotes, with emphasis on enterobacteria and their viruses. Topics include mutagenesis and isolation of mutants; genetic exchange, recombination and mapping; complementation, epistasis and suppression; transposons; gene expression and regulation; and genetics of bacterial pathogenesis.

BIOMI 652 (Section 04) Molecular Plant-Microbe Interactions (BIOPL 652, Sec 03)
Spring. 1 credit. Prerequisites: BIOGD 281, BIOBM 330 or 331 or 333, and BIOPL 653 (section 01) or their equivalents. S-U grades optional. Lecs, M W F 10:10 (12 lecs) Mar. 26-Apr. 21. S. C. Winans.
For course description, see BIOPL 652, Sec 04.

BIOMI 685 Advanced Bacterial Genetics (also BIOMI 485)
Fall. 2 credits. Limited to graduate students in Biological Sciences; see BIOMI 485. Prerequisites: BIOGD 281 or equivalent, BIOBM 330 or 331 and 332 or equivalent, and permission of instructor. Recommended: BIOMI 290 or equivalent. Lec, W 7:30–9:25 p.m.; disc, R 10:10. V. J. Stewart.
Concepts and principles of formal genetic analysis as applied to prokaryotes, with emphasis on enterobacteria and their viruses. Topics include mutagenesis and isolation of mutants; genetic exchange, recombination and mapping; complementation, epistasis and suppression; transposons; gene expression and regulation; and genetics of bacterial pathogenesis. Lectures and written assignments are shared with BIOMI 485; advanced topics from the primary literature are critically evaluated in the discussion.

BIOMI 692 Protein-Nucleic Acid Interactions
Spring. 3 credits. Prerequisites: BIOBM 330 or 331 or 333 and 633. Lecs, T R 10:10–11:25. J. D. Helmann.
The physical and chemical bases of protein-nucleic acid interactions are explored including both theory and specific examples. Proteins considered include bacterial non-specific and sequence specific DNA and RNA binding proteins, nucleic acid polymerases, recombinases, topoisomerases, DNA repair enzymes, and nucleases.

BIOMI 694 Genetics of Diverse Bacteria
Spring. 3 credits. Prerequisite: BIOMI 485 or equivalent. Lecs, M W 2:30–3:45. S. C. Winans.
Selected topics in bacterial diversity, with strong emphasis placed on underlying molecular mechanisms. Topics include interactions between bacteria and plants and animals, prokaryotic developmental biology, biodegradation of xenobiotics, and synthesis of antibiotics.

BIOMI 791 Advanced Topics in Bacterial Genetics
Fall or spring. 1 credit. May be repeated for credit. Prerequisite: graduate standing in microbiology. S-U grades only. Disc, T 4–5:00. Fall: S. C. Winans; spring: V. J. Stewart.
Discussion and critical evaluation of selections from the contemporary literature in bacterial genetics and molecular biology.

BIOMI 795–796 Current Topics in Microbiology
Fall, 795; spring, 796. 1/2 or 1 credit for each topic. May be repeated for credit. Designed primarily for graduate students in microbiology. Prerequisite: upper-level courses in microbiology. S-U grades only. Lecs to be arranged. Staff.
Lectures and seminars on special topics in microbiology.

BIOMI 797 Graduate Seminar in Microbiology
Fall and spring. 1 credit each semester. All students in the Graduate Field of Microbiology must enroll for at least their first three semesters in residence. Students are expected to lead discussions on recent primary literature in microbiology. S-U grades only. Sem to be arranged. Staff.

BIOMI 798 Graduate Research Seminar in Microbiology
Fall and spring. 1 credit each semester. Required of all graduate students in the Graduate Field of Microbiology. S-U grades only. Sem to be arranged. Staff.
A seminar relating to the research activities of those enrolled. Students who have completed the BIOMI 797 series requirement are required to present a seminar concerning their research interests and activities at least once each year.

[BIOMI 799 Microbiology Seminar
Fall and spring. Required of all graduate students in the Graduate Field of Microbiology and open to all who are interested. Not offered 1996–97. Sem to be arranged. Staff.]

Related Courses in Other Departments

Advanced Animal Virology, Lectures (Veterinary Microbiology 708)

Advanced Food Microbiology (Food Science 607)

Advanced Immunology Lectures (Biological Sciences [BIO G] 705 and Veterinary Microbiology 705)

Advanced Soil Microbiology (Soil, Crop, and Atmospheric Sciences 666)

Advanced Work in Bacteriology, Virology, or Immunology (Veterinary Microbiology 707)

Algal Physiology (Biological Sciences [BIOPL] 346)

Bacterial Plant Diseases (Plant Pathology 647)

Basic Immunology, Lectures (Biological Sciences [BIO G] 305 and Veterinary Microbiology 315)

Bioprocessing Applications in Agriculture (Agricultural and Biological Engineering 467)

Ciliophorology (Biological Sciences [BIOSM] 409)

Ecology of Soil-Borne Pathogens (Plant Pathology 644)

Food Microbiology, Laboratory (Food Science 395)

Food Microbiology, Lectures (Food Science 394)

Immunology of Infectious Diseases and Tumors (Biological Sciences [BIO G] 706 and Veterinary Microbiology 719)

Intermediate Soil Science: Chemistry and Microbiology (Soil, Crop, and Atmospheric Sciences 364)

Introduction to Bioprocess Engineering (Chemical Engineering 643)

Introduction to Scanning Electron Microscopy (Biological Sciences [BIO G] 401)

Introductory Mycology (Plant Pathology 309)

Light and Video Microscopy for Biologists (Biological Sciences [BIO G] 450)

Limnology: Ecology of Lakes, Lectures (Biological Sciences [BIOES] 457)

Magical Mushrooms, Mischievous Molds (Plant Pathology 201)

Microbiology for Environmental Engineering (Civil and Environmental Engineering 651)

Plant Virology (Plant Pathology 645)

Principles of Biogeochemistry (Biological Sciences [BIOES] 668)

NEUROBIOLOGY AND BEHAVIOR (BIONB)

BIONB 221 Neurobiology and Behavior I: Introduction to Behavior
Fall. 3 or 4 credits (4 credits with discussion section and written projects, or writing-intensive section). 4-credit option required of students studying neurobiology and behavior. Each discussion limited to 20 students, with preference given to students studying neurobiology and behavior. Not open to freshmen. Prerequisite: one year of introductory biology for majors. May be taken independently of BIONB 222. S-U grades optional. Lecs, M W F 12:20; disc to be arranged. H. K. Reeve and staff.
A general introduction to the field of behavior. Topics include evolution and behavior, behavioral ecology, sociobiology, chemical ecology, communication, rhythmicity, orientation and navigation, and hormonal mechanisms of behavior.

BIONB 222 Neurobiology and Behavior II: Introduction to Neurobiology
Spring. 3 or 4 credits (4 credits with discussion and written projects). 4-credit option required of students studying neurobiology and behavior. Each discussion limited to 20 students, with preference given to students studying neurobiology and behavior. Not open to freshmen. Prerequisites: one year of introductory biology for majors and one year of chemistry. May be taken independently of BIONB 221. S-U grades optional. Lecs, M W F 12:20; disc to be arranged. M. Salpeter and staff.
A general introduction to the field of cellular and integrative neurobiology. Topics include neural systems, neuroanatomy, developmental neurobiology, electrical properties of nerve cells, synaptic mechanisms, neurochemistry, motor systems, sensory systems, learning, and memory.

BIONB 322 Hormones and Behavior (also Psychology 322)
Spring. 3 or 4 credits; the 4-credit option involves a one-hour section once a week in which students are expected to read original papers in the field and participate in discussion. Limited to juniors and seniors; open to sophomores only by permission. Prerequisites: BIONB 221 or 222 or one year of introductory biology plus a course in psychology. S-U grades optional. Lecs, M W F 1:25; disc to be arranged. Staff.
Following a review of the neural and endocrine systems, this course connects endocrine physiology to specific behaviors observed in various species, including humans. Although the relationship between sexual physiology and behavior is strongly emphasized, the lectures also describe hormonal contributions to parental behavior, aggression, stress, learning and memory, homeostasis, and biology rhythms. Topics for the discussion sections are chosen by the students within the context of hormonal influences on behavior.

BIONB 324 Biopsychology Laboratory (also Psychology 324)
Fall. 4 credits. Limited to 20 upperclass students. Prerequisites: laboratory experience in biology or psychology, BIONB 221 and 222 or PSYCH 123 and 222; and permission of instructor. Labs, T R 1:25–4:25. T. J. DeVoogd.
Experiments designed to provide research experience in animal behavior (including learning) and its neural and hormonal mechanisms. A variety of techniques, species, and behavior patterns are included. Live animals are used in the laboratory.

BIONB 325 Neurodiseases - Molecular Aspects
Fall. 3 credits. Prerequisites: two courses from BIONB 222, BIOGD 281, BIOBM 330, or 331; co-registration in one of the two is acceptable. S-U grades optional. Offered alternate years. Lecs, T R 9:05; disc, T 2:30. T. R. Podleski.
The intent of this course is to teach students how to use recombinant DNA techniques for the study of neurodiseases. How are genes responsible for diseases identified and how are the functions of these genes studied? Attention is focused on those neural diseases in which significant advances have been made using these techniques, for example, Alzheimer's, Huntington's, color blindness, affective disorders, disorders affecting ion channels, and muscular dystrophies. In addition to the molecular studies, when appropriate, time is devoted to discussions of other aspects of the diseases. Emphasis is placed on how these studies provide a useful approach to studying the nervous system by exposing the functions of genes that would be difficult to identify in other ways.

[BIONB 326 The Visual System
Spring. 4 credits. Prerequisite: BIONB 222 or BIOAP 311, or permission of instructor. S-U grades optional. Offered alternate years. Not offered 1996–97. Lecs, M W F 10:10; disc, 1 hour each week to be arranged. H. C. Howland.
The visual systems of vertebrates are discussed in breadth and depth. Topics covered include the optics of eyes, retinal neurophysiology, structure and function of higher visual centers, and ocular development.]

BIONB 328 Biopsychology of Learning and Memory (also Psychology 332)
Spring. 3 credits. Prerequisites: one year of biology and either a course in biopsychology or BIONB 222. Lecs, M W F 11:15. T. J. DeVoogd.
This course surveys the approaches that have been or are currently being used in order to understand the biological bases for learning and memory. Topics include invertebrate, "simple system" approaches, imprinting, avian song learning, hippocampal and cerebellar function, and human pathology. Many of the readings are from primary literature.

[BIONB 396 Introduction to Sensory Systems (also Psychology 396 and 696)
Spring. 3 or 4 credits (4 credits with term paper). Registration for the 4-credit option requires permission of instructor. Prerequisites: an introductory course in biology or biopsychology, plus a second course in neurobiology or behavior or perception or cognition or biopsychology. Students are expected to have elementary knowledge of perception, neurophysiology, behavior, and chemistry. No auditors. Offered alternate years. Not offered 1996–97. Lecs, M W F 10:10. B. P. Halpern.
This course is taught using the Socratic method, in which the instructor asks questions of the students. Students read, analyze, and discuss in class difficult original literature dealing with both those characteristics of sensory systems that are common across living organisms and those sensory properties which represent adaptations of animals to particular habitats or environments. Classroom discussion can increase, but not decrease, a student's final grade. There are two preliminary exams and a final exam. The principles and limitations of major methods used to examine sensory systems are considered. General principles of sensory systems and auditory, visual, and somesthetic systems are covered. One aspect of each system (e.g., localization of objects in space by sound, color vision, and thermoreception) is selected for special attention. Two or more textbooks, and a course packet of reproduced articles are used. At the level of *An Introduction to the Physiology of Hearing,* 2nd edition, by J. O. Pickles; *Physiological acoustics, neural coding, and psychoacoustics,* by W. L. Gulick, G. A. Gescheider, and R. D. Frisina; *The Retina: An approachable part of the brain,* by J. E. Dowling; *Handbook of Physiology—The Nervous System. III. Sensory Processes,* edited by J. M. Brookhard and V. B. Mountcastle.]

BIONB 420 Topics in Neurobiology and Behavior
Fall or spring. Variable credit. May be repeated for credit. Primarily for undergraduates. S-U grades optional. To be arranged. Staff.
Courses on selected topics in neurobiology and behavior; can include lecture and seminar courses. Topics, instructors, and time of organizational meetings are listed in the division's catalog supplement issued at the beginning of the semester.

[BIONB 421 Effects of Aging on Sensory and Perceptual Systems (also Psychology 431 and 631)
Fall. 3 or 4 credits (4 credits with term paper). Limited to 25 students. Prerequisites: introductory course in biology or psychology, plus a second course in perception, neurobiology, cognition, or

biopsychology. No auditors. S-U grades optional. Offered alternate years. Not offered 1996–97. Lecs, T R 10:10–11:25. B. P. Halpern.

A literature-based examination of post-maturation changes in the perceptual, structural, and physiological characteristics of somesthetic, chemosensory, visual and auditory systems. Emphasis is on human data, with non-human information included when especially relevant. The course examines the current developments in human sensory prosthetic devices, and in regeneration of receptor structures. Brief written statements (preferably by electronic mail) of questions and problems related to each set of assigned readings are required at least one day in advance of each class meeting. This course is taught using the Socratic Method, in which the instructor asks questions of the students. Students are expected to come to each class having already done, and thought about, the assigned readings.]

[BIONB 422 Modeling Behavioral Evolution

Spring. 4 credits. Limited to 25 students. Prerequisites: BIONB 221, one year of calculus, one course in probability or statistics, and *permission of instructor* (Office: W309 Mudd Hall; phone: 254-4352). This course is open to advanced undergraduates and graduate students. S-U grades optional. Not offered 1996–97. Lecs, T R 2:30–4:00; computer lab, one class period per week to be arranged. H. K. Reeve.

This is an intensive lecture and computer lab course on modeling strategies and techniques in the study of behavioral evolution. Population genetics (including quantitative genetics), static optimization, dynamic programming, and game-theoretic methods are emphasized. These approaches are illustrated by application to problems in optimal foraging, sexual selection, sex ratio evolution, animal communication, and the evolution cooperation and conflict within animal social groups. Students learn to assess critically recent evolutionary theories of animal behavior, as well as to develop their own testable models for biological systems of interest or to extend pre-existing models in novel directions. The *Mathematica* software program is used as a modeling tool in the accompanying computer lab (no prior experience with computers required).]

[BIONB 423 Neurogenetics

Fall. 3 credits. Limited to junior, senior, and graduate students. Prerequisites: permission of instructor, one year of introductory biology or equivalent, and BIOGD 281. Strongly recommended: BIONB 222. S-U grades optional. Offered alternate years. Not offered 1996–97. Lecs, T R 2:30; disc, R 3:35. A. M. Schneiderman.

Lectures, discussions, and student presentations focus on the uses of genetics for the study of the nervous system. Emphasis is on recent advances in genetic and molecular biological techniques and their application to the study of neural development and behavior. Both invertebrate and vertebrate systems are discussed, and main consideration is given to the fruit fly and the mouse. Readings are taken primarily from original journal articles.]

[BIONB 424 Neuroethology (also Psychology 424)

Spring. 3 credits. Prerequisites: BIONB 221 and 222. Offered alternate years. Not offered 1996–97. Lecs, T 9:05–11:05; R 9:05–9:55. C. D. Hopkins.

In the 1950s through the 1970s, ethologists attempted to understand the mechanisms of animal behavior through the use of comparative methods, evolutionary analysis, careful observations of animals in their native habitats, and clever experimentation. Now, with the explosion of knowledge and techniques in the neurosciences, many of the ethologist's mechanisms are being explained in terms of neural systems. This course reviews the status of research in neuroethology, including mechanisms of acoustic communication in insects and in verebrates, echolocation in bats and sound localization in owls, electroreception and electrolocation, and visual processing. In addition, the course reviews studies of the neural systems involved in decision making, in initiating action, and in coordinating fixed acts. Assigned readings include original articles from the scientific literature. A term paper or equivalent is required. Recitations scheduled in class.]

BIONB 425 Natural History of Ion Channels

Spring. 3 credits. Limited to 20 students. Prerequisite: BIONB 222. S-U grades optional. Offered alternate years. D. McCobb.

Course takes a broad view of ion channels and cellular bioelectricity, with emphasis on the gene superfamily including voltage-gated channels. Evolutionary divergence is considered across phylogenetic history and tissue differentiation. Functional and structural variety, particularly in neural cells, examined from modern electrophysiological and molecular biological perspectives. Contributions to behavioral plasticity and neural development are considered.

[BIONB 427 Animal Social Behavior

Fall. 4 credits. Limited to 30 students. Prerequisites: BIONB 221 and BIOES 261 or 278, and advance permission of instructor. S-U grades optional, with permission of instructor. Offered alternate years. Not offered 1996–97. Lecs and discs, T R 2:30–4:25. S. T. Emlen.

An intensive course for upper-division students interested in behavorial ecology and sociobiology. Lectures, discussions, and student presentations examine topics including adaptation, spacing systems, mating systems, sexual selection, sex ratios, inbreeding and outbreeding, mate choice, conflict and cooperation in animal societies, and the evolution of deceit, honesty, and altruism.]

BIONB 428 Topics in Behavior

Fall or spring. 2–4 credits. (Credits based on number of lectures and/or field exercises as outlined in the division's catalog course supplement and subject to approval through the associate director's office.) May be repeated for credit. Primarily for undergraduates. S-U grades optional.

Courses on selected topics in behavior; can include lecture and seminar courses; may include laboratory. Past topics have included animal orientation, insect behavior, biorhythms, and communication. Topics, instructors, and time of organizational meeting are listed in the division's catalog supplement issued at the beginning of each semester.

[BIONB 429 Olfaction and Taste: Structure and Function (also Psychology 429)

Fall. 3 or 4 credits (4 credits with term paper or research project, which can, but need not, study nonhuman vertebrates). Preference given to junior and senior psychology and biology majors and graduate students. Graduate students, see PSYCH 629. Prerequisite: a 300-level course in biopsychology or equivalent. Offered alternate years. Not offered 1996–97. Lecs, T R 9:05. B. P. Halpern.

The structural and functional characteristics of olfaction and taste are explored by reading and discussing current literature in these areas. Structure is examined at the light levels of electron microscopes as well as at the molecular level. Function is examined primarily in its neurophysiological and biochemical aspects. The emphasis is on vertebrates, especially air-breathing vertebrates in the case of olfaction, although there is some coverage of invertebrate forms. A textbook and a course packet of reproduced articles are used. At the level of *Smell and Taste in Health and Disease*, edited by T. V. Getchell, R. L. Doty, L. M. Bartoshuk, and J. B. Snow; *The Neurobiology of Taste and Smell*, edited by T. E. Finger and W. L. Silver.]

BIONB 490 Neotropical Behavior/Ecology Field Semester

Spring. 15 credits. Limited to 2–4 juniors or senior students. Prerequisites: BIONB 221 or BIOES 260 or their equivalents and permission of instructor. S. T. Emlen, P. H. Wrege.

Field studies in the Neotropics conducted under the auspices of Cornell University and the Smithsonian Tropical Research Institute (STRI) in central Panama. Students live in the town of Gamboa, perform research in the lowland tropical rain forest of Soberina National Park, and visit research projects on the Barro Colorado Island, Gigante Peninsula, Pipeline Road, Metropolitan Park, and elsewhere.

The semester includes three units of study: (1) Field Methods in Behavior and Ecology (4 credits). Weekly discussion meetings; through selected readings students examine the objectives, strengths, and limitations of the field methods being used on an ongoing research project on role reversal in a neotropical shorebird, the Wattled jacana. Students learn about a wide variety of field methods through short-term visits to other field projects sponsored by the Smithsonian. (2) Topics in Neotropical Biology (4 credits). Weekly seminars on behavior, ecology, physiology, and systematics presented by Smithsonian staff and visiting scientists. Topics may also include the geology and paleontology of the Isthmus regions. Students prepare a paper exploring the status and interdependence of two topics introduced in the seminar series. (3) Independent Research in Behavioral Ecology (7 credits). A comprehensive experience in field research, through active participation in ongoing research. This unit of the program includes readings on, and discussions of, the conceptual framework underlying the project; participation in the design of experimental protocols and data acquisition methods; capture, marking, and measuring of study animals; intensive use of methods to study animal social behavior in

the field; organization and entry of data for analysis; and examination and statistical analysis of data. Students are expected to develop an independent research project within the framework of the ongoing Jacana Research Project.

BIONB 491 Principles of Neurophysiology
Spring. 4 credits. Limited to 20 students. Prerequisite: BIONB 222 or written permission of instructor. S-U grades optional for graduate students. Lecs, M W 10:10; lab, M or T 12:20–4:25; additional hours to be arranged. B. R. Johnson.
A laboratory-oriented course designed to teach the theory and techniques of modern cellular neurophysiology. Lecture time is used to introduce laboratory exercises and discuss results, to supplement laboratory topics, and for discussion of primary research papers. Extracellular and intracellular recording and voltage clamp techniques are used to analyze motor neuron and sensory receptor firing properties, and examine the cellular basis for resting and action potentials and synaptic transmission. A variety of preparations are used as model systems. Computer acquisition and analysis of laboratory results are emphasized.

[BIONB 492 Sensory Function (also Psychology 492)
Spring. 3 or 4 credits. (The 4-credit option involves a one-hour section once a week, in which students are expected to participate in discussion. The 4-credit option is not always offered.) Prerequisite: a 300-level course in biopsychology or BIONB 222 or BIOAP 311, or permission of instructors. Students are expected to have a knowledge of elementary physics, chemistry, and behavior. S-U grades optional. Offered alternate years. Not offered 1996–97. Lecs, M W F 10:10; disc, hours to be arranged. B. P. Halpern, H. C. Howland.
This course covers classical topics in sensory function such as vision, hearing, touch, and balance, as well as some more modern topics like sensory coding, location of stimulus sources in space, the development of sensory system, and nonclassical topics such as electroreception and internal chemoreceptors. Both human and nonhuman systems are discussed. In all cases the chemical, physical, and neurophysiological bases of sensory information are treated, and the processing of this information is followed into the central nervous system. At the level of *The Senses*, edited by Barlow and Mollon, and *An Introduction to the Physiology of Hearing, 2nd edition*, by Pickles.]

[BIONB 493 Developmental Neurobiology
Fall. 3 credits. Prerequisite: BIONB 222 or permission of instructor. S-U grades optional, with permission of instructor. Offered alternate years. Not offered 1996–97. Lecs, M W F 9:05. R. Booker.
Lectures covering the development of the nervous system, taking examples from both vertebrates and invertebrates. Emphasis is on cellular and molecular issues, that is, How do nerve cells differentiate both morphologically and biochemically? The role of cues such as hormones and developmental genes in neural development is discussed. Readings are taken from original journal articles.]

[BIONB 494 Comparative Vertebrate Neuroanatomy
Spring. 3 credits. Intended for juniors, seniors, and graduate students. Prerequisite: BIONB 222 or equivalent. S-U grades optional. Offered alternate years. Not offered 1996–97. Lecs, T R 10:10–11:30. A. H. Bass.
Organization and evolution of neuroanatomical pathways as substrates for species-typical vertebrate behaviors. The course is divided into three major sections: development, general principles of brain organization, and co-evolution of vertebrate brain and behavior.]

BIONB 496 Bioacoustic Signals in Animals and Man
Fall. 3 credits. Limited to 12 junior, senior, and graduate students. Prerequisites: one year of introductory biology, PHYS 101–102 or 207–208, and permission of instructor. S-U grades optional. Offered alternate years. Next offered spring 1999 and alternate spring semesters thereafter. Lecs, M W 9:05; lab to be arranged. C. W. Clark, R. R. Hoy.
Humans and most terrestrial animals live in a world of sound. Acoustic signals mediate social interactions and predator-prey behavior. This course teaches students about animal acoustical communication by introducing them to the different communication systems that are based on sound. The course presents the physical properties of sound, the physiological mechanisms of sound production and hearing, and an analysis of the behavioral context of signaling. In the laboratory students learn how to record, synthesize, and analyze acoustic signals with the aid of tape recorders and the Macintosh computer. Laboratories are designed around the lecture material and provide "real-world" exercises designed to stimulate discovery of the fundamental principles described in class. Class research projects on a selected topic in bioacoustics are required. The laboratory is based on software instrumentation running on a Macintosh II platform equipped with A/D-D/A data acquisition boards.

[BIONB 497 Neurochemistry and Molecular Neurobiology
Fall. 3 credits. Limited to 30 students. Prerequisites: BIONB 222 and either BIOBM 330 or 331 and 332, or permission of instructor. S-U grades optional. Offered alternate years. Not offered 1996–97. Lecs, T R 9:05; disc, T 2:25. R. M. Harris-Warrick.
This course focuses primarily on the biochemistry/molecular biology of neurons. Emphasis is on the molecular properties of these cells that account for their unique function. The presynaptic regulation of release and postsynaptic mechanism of action of the major classes of neurotransmitters are discussed, as well as selected neuromodulators and hormones. Readings are selected primarily from research journals.]

[BIONB 623 Chemical Communication (also Chemistry 622)
Fall. 3 credits. Primarily for research-oriented students. Limited to 30 students. Prerequisites: one year of introductory biology for majors or equivalent, course work in biochemistry, and CHEM 358 or equivalent. Offered alternate years. Not offered 1996–97. Lecs, M W 1:25; disc, F 1:25. J. Meinwald, T. Eisner, W. L. Roelofs, and guest lecturers.
The production, transmission, and reception of chemical signals in communicative interactions of animals, plants, and microorganisms. Studies of insects are emphasized. Specific topics are treated with varying emphasis on chemical, biochemical, ecological, behavioral, and evolutionary principles. The discussion sessions focus on readings from the recent literature and involve student-led discussions of contemporary topics.]

BIONB 626 Sex Differences in Brain and Behavior (also Psychology 524)
Spring. 2 credits. Limited to 12 students. Prerequisite: BIONB 322 or permission of instructor. Discs and sems to be arranged. T. J. DeVoogd.
A survey of the newly discovered animal models for sex differences in the brain. Topics include the role of steroids in brain development, whether hormones can modify the structure of the adult brain, and the consequences of such sex differences in anatomy for behavior.

BIONB 720 Seminar in Advanced Topics in Neurobiology and Behavior
Fall or spring. Variable credit. May be repeated for credit. Primarily for graduate students; written permission of instructor required for undergraduates. S-U grades optional. Sem to be arranged. Staff and students.
Designed to provide several study groups each semester on specialized topics. A group may meet for whatever period is judged adequate to enable coverage of the selected topics. Ordinarily, topics are selected and circulated during the preceding semester. Discussion of current literature is encouraged. Suggestions for topics should be submitted by faculty or students to the chair of the Section of Neurobiology and Behavior.

BIONB 721 Introductory Graduate Survey in Neurobiology and Behavior
Fall. 2 credits each term. Required of graduate students majoring in neurobiology and behavior. Concurrent registration in BIONB 221 and 222 not required. S-U grades only. Lecs and discs, T R 11:15–12:05, alternate weeks. T. D. Seeley.
Lectures by faculty and student-led discussions on topics of current importance in neurobiology and behavior. Topics are linked to the materials presented in BIONB 221 and 222. Class meets twice a week, every other week. Students are required to write four term papers, over the two semesters, on selected topics in two of three sub-areas: (1) cellular and molecular neurobiology; (2) integrative neurobiology; (3) behavior.

BIONB 723 Advanced Topics in Animal Behavior
Fall or spring. Variable credit. May be repeated for credit. Primarily for graduate students in behavior. Prerequisite: permission of instructor. S-U grades optional. Sem to be arranged. Staff.
A seminar on a specific topic in animal behavior. The instructor presents lectures during the first few course meetings; the remainder of the course is devoted to student presentations. Topic and instructor are listed in the division's catalog supplement issued at the beginning of the semester.

BIONB 724 Field Methods in Animal Behavior
Fall or spring. Variable credit. May be repeated for credit. Primarily for graduate students in behavior. Prerequisite: permission of instructor. S-U grades optional. Sem and fieldwork to be arranged. Staff.
A seminar-field experience course designed for first-year graduate students in animal behavior. Weekly seminars discussing field methodology, data collection, and hypothesis testing are followed by an intensive period (ten days to two weeks) in the field. Specific topics and field sites vary from semester to semester. Topic and instructor are listed in the division's catalog supplement issued at the beginning of the semester.

BIONB 790 Advanced Topics in Cellular and Molecular Neurobiology
Fall or spring. Variable credit. May be repeated for credit. Limited to graduate students and advanced undergraduates studying neurobiology and behavior. Prerequisite: BIONB 222. S-U grades optional. Lecs and sem to be arranged. Staff.
A lecture-seminar course on selected topics in cellular and molecular neurobiology. Students read original papers in the scientific literature and lead discussions of these articles. Suggestions for topics may be submitted by faculty or students to the chair of the Section of Neurobiology and Behavior. Topic and instructor are listed in the division's catalog supplement issued at the beginning of the semester.

BIONB 792 Advanced Laboratory in Cellular and Molecular Neurobiology
Fall or spring. 2 credits. May be repeated for credit. Primarily for graduate students. Prerequisites: BIOBM 330 or 331 or equivalent, BIONB 491 or equivalent, and written permission of instructor. S-U grades optional. Lab to be arranged. Staff.
A two-week intensive laboratory course designed to provide experience with a specific technique currently used in cellular and molecular neurobiology. The technique under study and instructor in charge vary from semester to semester and are listed in the division's catalog supplement issued at the beginning of the semester.

BIONB 793 Advanced Topics in Integrative Neurobiology
Fall or spring. Variable credit. May be repeated for credit. Primarily for graduate students; written permission of instructor required for undergraduates. S-U grades optional. Lecs and discs to be arranged. Staff.
A course designed to provide in-depth knowledge of current research in anatomical and physiological bases of vertebrate and invertebrate behavior. Readings are primarily from specialty books and selected journal articles. Topic and instructor are listed in the division's catalog supplement issued at the beginning of the semester.

BIONB 794 Advanced Laboratory Techniques in Integrative Neurobiology
Fall or spring. Variable credit. May be repeated for credit. Prerequisite: permission of instructor based upon a personal interview. Lab to be arranged. Staff.
A laboratory in the integrative, or neuroethological, approach to studies of animal behavior. Designed to provide practical working knowledge of research methods in anatomical, physiological, and behavioral approaches to studies of vertebrate and invertebrate behavior. Laboratory technique to be covered and instructor are listed in the division's catalog supplement issued at the beginning of the semester.

Related Courses in Other Departments

Animal Behavior (Psychology 535)

Biochemistry and Human Behavior (Psychology 361 and Nutritional Sciences 361)

Brain and Behavior (Psychology 425)

Developmental Biopsychology (Psychology 422)

Evolution of Human Behavior (Psychology 326)

Human Behavior: A Sociobiological Perspective (Anthropology 476)

Insect Behavior Seminar (Entomology 662)

Neurobiology of Animal Behavior (Biological Sciences [BIOSM] 327)

Primates and Evolution (Anthropology 490)

Primate Behavior and Ecology (Anthropology 390)

Teaching Experience (Biological Sciences [BIO G] 498)

Undergraduate Research in Biology (Biological Sciences [BIO G] 499)

PLANT BIOLOGY (BIOPL)

BIOPL 241 Introductory Botany
Fall. 3 credits. Lecs, T R 9:05; lab, M T W or R 1:25–4:25, or W 7:30–10:30 p.m. K. J. Niklas.
Introductory botany for those interested in the plant sciences. Emphasizes structure, reproduction, and classification of angiosperms and the history of life on earth. Laboratory emphasizes development of skills in handling plant materials, including identification. First and second weeks of laboratory are field trips, starting with the first day of classes. *Those who register for an evening laboratory are still required to attend the afternoon field trips.*

BIOPL 242 Plant Physiology, Lectures
Spring. 3 credits. Primarily for undergraduates in agricultural sciences, but also for any Biological Sciences students wanting to know about plant function. Suitable as a second-level course for nonmajors to satisfy the biology distribution requirement. Prerequisites: one year of introductory biology and/or BIOPL 241. Recommended: one year introductory chemistry. Concurrent enrollment in BIOPL 244 required of undergraduates except those majoring in the social sciences or humanities, for whom it is recommended. May not be taken for credit after BIOPL 342 except by written permission of instructor. Lecs, M W F 10:10. C. Reiss.
How plants function and grow. Examples deal with crop plants or higher plants where possible, though not exclusively. Topics include cell structure and function; plant metabolism, including photosynthesis; light relations in crops; plant-water relations; water uptake, transport, and transpiration; irrigation of crops; sugar transport; mineral nutrition; growth and development—hormones, flowering, fruiting, dormancy, and abscission; stress; tissue culture; and genetic engineering.

BIOPL 243 Taxonomy of Cultivated Plants
Fall. 3 credits. Prerequisite: one year of introductory biology or written permission of instructor. May not be taken for credit after BIOPL 248. Lecs, M W 10:10; labs, W 2–4:25. M. A. Luckow.
A study of ferns and seed plants, their relationships, and their classification into families and genera, emphasizing cultivated plants. Particular emphasis is placed on gaining proficiency in identifying and distinguishing families and in preparing and using analytic keys. Attention is also given to the economic importance of taxa, to the basic taxonomic literature, and to the elements of nomenclature.

BIOPL 244 Plant Physiology, Laboratory
Spring. 2 credits. Prerequisite: concurrent enrollment in BIOPL 242. May not be taken for credit after BIOPL 344. Disc and lab, M T W or R 12:20–4:25. C. Reiss.
Experiments exemplify concepts covered in BIOPL 242 and offer experience in a variety of biological and biochemical techniques, including use of small amounts of radioisotopes.

BIOPL 245 Plant Biology
Summer (6–week session). 3 credits. Limited to 24 students. Lecs, M-F 11:30–12:45; labs, M W 2–5:00. S. Williams.
Introductory botany, including plant identification. Emphasizes structure, reproduction, and classification of flowering plants. Most of the laboratory work is conducted outdoors in an area that surpasses most biological stations. Those who lack college-level biology are expected to work more closely with the instructor on supplemental instructional materials.

BIOPL 246 Plants and Civilization
Spring. 3 credits. Lecs, T R 11:15; disc, T or W 1:25 or W or R 12:20. D. M. Bates.
A consideration of the role that plants have played and continue to play in the evolution of human cultures. Emphasis is on the interactions between humans and the plant environment, the nature of plants and manner in which humans use and integrate them into their cultures, and the problems and concerns related to contemporary and future use of plant resources.

BIOPL 248 Taxonomy of Vascular Plants
Spring. 4 credits. Prerequisite: one year of introductory biology. May not be taken for credit after BIOPL 243. S-U grades optional. Lecs, M W F 9:05; lab, W or R 1:25–4:25. J. I. Davis.
An introduction to the classification of vascular plants, with attention to the goals of taxonomy, the processes of plant evolution, and the means of analyzing evolutionary relationships among plants. The laboratory concentrates on methods of plant identification and presents an overview of vascular plant diversity, with particular attention to the flowering plants.

BIOPL 341 Plants in Laboratory Teaching
Fall. 2 credits. Limited to 16 students. Prerequisite: one year of introductory biology. S-U grades optional. Disc and lab, T R 3:10–4:30. C. Reiss, D. J. Paolillo.

This course is intended for science education students who intend to teach biology at the high school level. The focus is on how to use plants in the biology laboratory in interesting ways, with particular emphasis on using plants to demonstrate basic biological principles. Hands-on experience is provided in experimental set-up and performance. Additional emphasis given to experimental design, data collection and analysis, and actual experience in a high school biology teaching laboratory.

BIOPL 342 Plant Physiology, Lectures
Spring. 3 credits. Prerequisites: one year of introductory biology and either concurrent enrollment in BIOPL 344 or written permission of instructor. May not be taken for credit after BIOPL 242 unless written permission is obtained from instructor. Lecs, T R 10:10–11:25. T. G. Owens.
An integrated and interdisciplinary study of the processes that contribute to the growth, competition, and reproduction of plants. Topics include, but are not limited to, plant water relations, membrane properties and processes, photosynthesis, plant respiration, mineral and organic nutrition, stress physiology, control of growth and development, and responses to the environment. Emphasis is on the relationship between structure and function from the molecular to the whole-plant level.

BIOPL 343 Molecular Biology and Genetic Engineering of Plants
Fall. 2 credits. Prerequisite: one year general biology or permission of instructor. S-U grades optional. Lecs, T R 11:15. M. E. Nasrallah.
An introduction to current studies involving recombinant DNA technology and its application to the analysis of basic plant processes. The course emphasizes genetic transformation methodology, molecular genetic approaches to the study of selected plant systems, and prospects for plant improvement using biotechnology. The course is directed at undergraduates who wish to become familiar with plants as experimental organisms. Selected topics attempt to illustrate the uniqueness of plant life and how it differs from other systems.

BIOPL 344 Plant Physiology, Laboratory
Spring. 2 credits. Prerequisite: concurrent enrollment in BIOPL 342. May not be taken for credit after BIOPL 244. Similar to BIOPL 244 but at a more advanced level. Lab, W 1:25–4:25; disc, W 12:20. C. Reiss.
Experiments exemplify concepts covered in BIOPL 342 and offer experience in a variety of biological and biochemical techniques, including use of small amounts of radioisotopes, with emphasis on experimental design.

[BIOPL 345 Plant Anatomy
Fall. 4 credits. Limited to 15 students. Prerequisite: one year of introductory biology or a semester of botany. Offered alternate years. Not offered 1996–97. Lecs, M W 9:05; labs, M W 2–4:25. D. J. Paolillo.
A descriptive course with equal emphasis on development and mature structure. Lecture, laboratory, and reading are integrated in a study guide. The laboratory offers the opportunity to develop the practical skills required to make anatomical diagnoses and to write anatomical descriptions.]

[BIOPL 346 Algal Physiology
Fall. 3 credits. Prerequisites: one year of introductory biology for majors and BIOPL 242 or 342, or permission of instructor. S-U grades optional. Offered alternate years. Not offered 1996–97. Lecs, T R 8:30–9:55. T. G. Owens.
This course takes an interdisciplinary approach to the study of algae with an emphasis on the physiology, biochemistry, and ecology of this diverse group of organisms. The algal classes are briefly described with consideration of traditional and emerging criteria for classification of the algae. The majority of the course focuses on interactions of algae with the physical/chemical environment, uptake of inorganic compounds, algal photosynthesis, metabolic strategies, and population dynamics of planktonic algae and benthic macrophytes. There is no laboratory section with this course.]

BIOPL 347 Laboratory in Molecular Biology and Genetic Engineering of Plants
Fall. 2 credits. Limited to 24 students. Prerequisite: BIOPL 343 or permission of instructor. Concurrent enrollment is BIOPL 343 is encouraged. S-U grades optional. Lab, W 1:25–4:25. M. E. Nasrallah.
The laboratory provides experience in handling and experimenting with the plant *Arabidopsis thaliana*. Selected experiments include the preparation and analysis of nucleic acids, methods used in the detection and isolation of plant genes, analysis of gene expression using antibody and nucleic acid probes, mutant isolation, and methods of gene transfer to plants.

[BIOPL 359 Biology of Grasses
Fall. 3 credits. Limited to 24 students. Prerequisite: one year of introductory biology or an introductory plant taxonomy course, or permission of instructor. S-U grades optional. Offered alternate years. Not offered 1996–97. Lecs, T R 10:10; lab, T 1:25–4:25. J. I. Davis.
Systematics and ecology of the graminoid plant families (grasses, sedges, and rushes), with principal emphasis on grasses. Major topics include taxonomy, phylogenetics, physiology, reproductive biology, ecotypic variation, speciation, biogeography, and population biology. The role of graminoids as ecosystem dominants, weeds, and the origins of cultivated species are discussed. Laboratory concentrates on the diversity of grasses.]

BIOPL 440 Phylogenetic Systematics
Fall. 4 credits. Limited to 24 students. Prerequisite: graduate standing or permission of instructor. Offered alternate years. Lecs, T R 10:10; labs, T R 2:00–4:25. K. C. Nixon.
Basic and advanced theory and methods of phylogenetic analysis. Students are introduced to cladistic analysis using parsimony and gain experience with computer-aided analysis of taxonomic data, including both morphological and molecular data sources. Topics discussed include applications of phylogenetic methods to biogeography and evolutionary studies.

BIOPL 441 Systematics and Evolution of Crops
Fall. 2 credits. Prerequisite: an advanced-level course in the plant sciences with taxonomic content or permission of instructor. Offered alternate years. Lecs, R 12:20–2:15. D. M. Bates.
An integrated study of the systematics and evolution of agronomic and horticultural species. Processes of domestication, the evolutionary history of selected cultigens, the nature of weeds and land races, classification and nomenclature as applied to cultivated plants, and underexploited plant resources are among the topics considered.

BIOPL 443 Topics and Research Methods in Systematics
Fall or spring. 1–2 credits (1 credit per section). Prerequisite: written permission of instructor. S-U grades optional.
A series of 1-credit modules on specialized topics in systematics. Topics and instructors vary each semester. Topics and instructors are listed in the division's catalog supplement issued at the beginning of the semester.

Section 01 Pollen Structure and Morphology
Fall. 1 credit. Lecs, M W 12:20–1:10 (12 lecs) Sept. 2-Oct. 9. W. L. Crepet.
A broad introduction to variation in the structure and morphology of pollen, principally in the contexts of systematic significance and evolution. Pollen development and function in pollination are discussed.

Section 02 Polyploidy in Plants
Fall. 1 credit. Lecs, M W 12:20–1:10 (12 lecs) Oct. 16-Dec. 2. J. J. Doyle, J. I. Davis.
An introduction to the process of polyploidy, with emphasis on its evolutionary and phylogenetic significance. Origins and evolution of polyploid complexes in wild and cultivated plant groups are discussed.

BIOPL 444 Plant Cell Biology
Fall. 4 credits. Limited to 24 students. Prerequisites: one year of introductory biology or permission of instructor. Lecs, M W F 9:05; lab, M or W 1:25–4:25. R. O. Wayne.
Evidence from microscopy, physiology, biochemistry, and molecular biology is used to try to unravel the mystery of the living cell. The dynamics of protoplasm, membranes, and the various organelles are studied. The mechanisms of cell growth and division, the relationship of the cytoskeleton to cell shape and motility, the interaction of the cell with its environment, and the processes that give rise to multicellular differentiated plants are investigated.

BIOPL 445 Photosynthesis
Fall. 3 credits. Prerequisites: CHEM 104 or 208, MATH 106 or 111, and either PHYS 102 or 208 or permission of instructor. Offered alternate years. Lecs, M W F 10:10. T. G. Owens.
A detailed study of the processes by which plants use light energy to grow. Structure of the photosynthetic apparatus, light absorption and antenna processes, photochemistry, and electron transport are emphasized. The course incorporates biophysical, biochemical, physiological, and molecular aspects of photosynthesis. Photosynthetic carbon metabolism is not covered in detail. Discussions include relevant material in bacterial, algal, and higher-plant photosynthesis.

[BIOPL 447 Molecular Systematics
Fall. 3 credits. Prerequisites: BIOES 278 or BIOGD 281 or BIOBM 332, or written permission of instructor. Offered alternate years. Not offered 1996–97. Lecs, T R 8:30–9:55. J. J. Doyle.
The study of variation at the molecular level and its application to the taxonomy and evolution of plants, particularly angiosperms. Emphasis is on the use of molecular evidence, particularly DNA data, for reconstructing phylogenies. Theory and methods of phylogenetic reconstruction are discussed. The organization and evolution of nuclear, mitochondrial, and chloroplast genomes, genes, and gene products are described from the standpoint of their utility for addressing a diversity of evolutionary questions. These questions span the entire taxonomic spectrum, and include such issues as the origin of angiosperms, evolution of species related to important crop plants, and population studies of hybridization.]

BIOPL 448 Plant Evolution and the Fossil Record
Spring. 3 credits. Prerequisite: BIOPL 241 or equivalent, or permission of instructor. Offered alternate years. Lecs, T R 9:05; lab, R 12:20–2:15. K. J. Niklas, W. L. Crepet.
An introduction to evolution, surveying major changes in plants from the origin of life to the present. Emphasis is placed on plant form and function, adaptations to particular ecologic settings, and evolutionary theory as it relates to plants.

BIOPL 453 Principles and Practice of Historical Biogeography (also Entomology 453)
Fall. 3 credits. Prerequisite: a course in systematics or permission of instructor. S-U grades optional. Lecs, T R 10:10; lab/disc, R 2:30–4:25. J. K. Liebherr, M. A. Luckow.
This course provides a comprehensive survey of the current methods and techniques used in historical biogeography, and the development of modern biogeographic theory in the context of classical and ecological methods of analysis. Brief summaries of geological and paleontological aspects of biogeography are presented, and large-scale biogeographic patterns discussed. The laboratories focus on hands-on computer applications of modern techniques and discussion of controversial issues in biogeography.

[BIOPL 466 Physiological Plant Ecology, Lectures (BIOES 466)
Spring. 3 credits. Limited to 35 students. Prerequisite: BIOES 261 or introductory plant physiology. S-U grades optional, with permission of instructor. Offered alternated years. Not offered 1996–97. Lecs, T R 10:10–11:25; optional disc to be arranged. T. E. Dawson.
For course description, see BIOES 466.]

[BIOPL 468 Physiological Plant Ecology, Laboratory (BIOES 468)
Spring. 2 credits. Limited to 15 students. Prerequisite: previous or concurrent enrollment in BIOES 466. Offered alternated years. Not offered 1996–97. Lab, T 1:25–4:25, plus additional lab hours to be arranged; 1 weekend field trip required. Fee, $15. T. E. Dawson.
For course description, see BIOES 468.]

BIOPL 641 Laboratory in Plant Molecular Biology
Spring. 4 credits. Prerequisites: BIOGD 281 or equivalent, BIOBM 330 or 331 or equivalent, and permission of instructor. S-U grades optional. Lab, T 9:05–4:30. J. B. Nasrallah, M. R. Hanson, S. D. Tanksley.
Selected experiments on genome organization, gene expression, and gene transfer in plants. The course emphasizes the application of molecular biology methodology to plant systems. Students may have additional lab time to complete assignments.

BIOPL 642 Plant Mineral Nutrition (also Soil, Crop, and Atmospheric Sciences 642)
Spring. 3 credits. Prerequisite: BIOPL 342 or equivalent. Offered alternate years. Lecs, M W F 10:10. L. V. Kochian, R. M. Welch.
A detailed study of the processes by which plants acquire and use mineral nutrients from the soil. Topics include the uptake, translocation, and compartmentation of mineral elements; root-soil interactions; the metabolism of mineral elements; the involvement of mineral nutrients in various physiological processes; and the nutrition of plants adapted to extreme environmental stresses (e.g., acid soils). Specific mineral elements are emphasized to illustrate these topics.

[BIOPL 643 Plant Physiology, Advanced Laboratory Techniques
Fall. 4 credits. Prerequisites: organic chemistry, biochemistry, and a course in plant physiology. S-U grades only. Offered alternate years. Not offered 1996–97. Lab, T or W 8–5:00; disc, M 4:30–5:30. A. T. Jagendorf and staff.
An introduction to some modern methods in experimental plant biology. A partial list of techniques used includes fluorescence measurements, infrared CO_2 analysis, gel electrophoresis and Western blots, cellular electrode measurements, microtiter plate technology for enzyme assays, sensitive growth measurements, HPLC and GC-MS, and computer interfacing with laboratory equipment.]

[BIOPL 644 Plant Growth and Development
Spring. 3 credits. Prerequisites: BIOPL 345 and either 242 or 342 or their equivalents, or written permission of instructor. Offered alternate years. Not offered 1996–97. Lecs, M W F 9:05. P. J. Davies, D. J. Paolillo.
Explores the changes that occur during plant growth and development and their control: morphological and anatomical changes in apices, tissue differentiation, organ formation, embryo development, gene regulation, hormone action and interaction, the influence of light in development, flowering, fruiting, dormancy, abscission, and senescence.]

[BIOPL 645 Families of Tropical Flowering Plants
Fall. 1 credit. Prerequisite: written permission of instructor. S-U grades only. Offered alternate years. Not offered 1996–97. Lec and disc, F 11:15. K. C. Nixon.
The families of flowering plants encountered solely or chiefly in tropical regions are considered in lectures, discussions, and demonstrations, with the aim of providing basic points of recognition for, and an understanding of, diversity and relationships in these families for the student venturing into the tropics.]

[BIOPL 646 Families of Tropical Flowering Plants: Field Laboratory
Intersession. 3 credits. Limited to 20 students, with preference given to graduate students from member institutions of the Organization for Tropical Studies. Prerequisite: BIOPL 243 or 248 or equivalent. Recommended: BIOPL 645. S-U grades only. For more details and application, contact the L. H. Bailey Hortorium, 467 Mann Library. Offered alternate years. Not offered 1996–97. K. C. Nixon.
An intensive orientation to families of tropical flowering plants represented in forests of the American tropics. Emphasis on field identification combined with laboratory analysis of available materials in a "whole-biology" context.]

BIOPL 647 Seminar in Systematic Botany
Fall or spring. 1 credit. May be repeated for credit. Prerequisite: written permission of course coordinator required for undergraduates. S-U grades optional. Sem, T 11:15–1:10. Bailey Hortorium staff.
Lectures and discussions led by staff, visitors, and students on topics of current importance to systematic botany.

BIOPL 648 Plant Biochemistry
Spring. 3 credits. Prerequisites: organic chemistry, biochemistry, and a course in plant physiology. Offered alternate years. Lecs, M W F 9:05. A. T. Jagendorf and staff.
Selected areas of plant biochemistry are reviewed in the context of the plant life cycle and responses to the environment. Topics include metabolism of lipids, carbohydrates, organic acids, phenolic compounds, and proteins; nitrogen and sulfur assimilation; respiration; photosynthesis; development and replication of chloroplasts; and cell-wall composition and properties. Attention is paid to operation of control mechanisms.

[BIOPL 649 Transport of Solutes and Water in Plants
Fall. 3 credits. Prerequisite: BIOPL 342 or equivalent. Offered alternate years. Not offered 1996–97. Lecs, T R 10:10–11:30. R. M. Spanswick.
Transport of ions, water, and organic materials in plants; mechanisms of ion transport; relationships between ion transport and metabolism; ion uptake and transport in higher plants; phloem transport; and water relations of single cells and whole plants.]

BIOPL 651 Quantitative Whole-Plant Physiology
Fall. 3 credits. Prerequisites: introductory physics, calculus, and plant physiology. S-U grades only. Offered alternate years. Lecs, T R 10:10–11:30. R. M. Spanswick.
An exploration of the extent to which physiological processes and their interactions can be formulated in a quantitative manner and integrated to describe various aspects of plant behavior, including growth and yield. Consideration is given to characterization of the plant environment, energy balance, gas exchange, water relations, photosynthesis, respiration, translocation, nutrient supply, and the timing of developmental events.

BIOPL 652 Plant Molecular Biology II
Spring. 1–4 credits (1 credit per section). Prerequisites: BIOGD 281 and BIOBM 330 or 332, or their equivalents. Recommended: BIOBM 331. S-U grades optional.
A series of four-week modules on specialized topics. Coordinator: S. H. Howell.

Section 01 Molecular Plant-Pathogen Interactions (also Plant Pathology 662)
1 credit. Lecs, M W F 10:10 (12 lecs) Jan. 22-Feb. 17. O. C. Yoder, A. R. Collmer, T. P. Delaney.
An examination of the molecular properties that control the development of host-parasite interactions in both microorganisms (bacteria and fungi) and higher plants. Contemporary theories describing the genetic and molecular mechanisms of microbial pathogenesis and plant resistance are discussed.

Section 02 Molecular Aspects of Plant Development II
1 credit. S-U grades optional. Lecs, M W F 10:10 (12 lecs) Feb. 19-Mar. 24. S. H. Howell.
The molecular genetics of plant development. This module focuses on vegetative development and includes topics such as the development of the shoot, root, and vasculature and the operation of the vegetative shoot apical meristem. The module is a companion to BIOPL 653, Sec 04 (Plant Development I), which covers molecular aspects of reproductive development.

Section 03 Molecular Plant-Microbe Interactions
1 credit. S-U grades optional. Lecs, M W F 10:10 (12 lecs) Mar. 26-Apr. 21. S. C. Winans.
Course focuses on the interactions of *Agrobacteria* and *Rhizobia* with plants. Topics on *Agrobacterium*-plant interactions include plant-microbe recognition mechanisms, T-DNA transfer process, oncogenesis and use of *Agrobacterium* to produce transgenic plants. Topics on *Rhizobium*-plant interactions include regulation of nitrogenase activity and expression, organization and function of the *sym* plasmid, nodule development, and plant genetics involved in plant-microbe interaction.

Section 04 Plant Gene Evolution and Phylogeny
1 credit. Lecs, M W F 1:25 (12 lecs) Mar. 26-Apr. 21. J. J. Doyle.
Practical applications of molecular systematics/evolution for plant molecular biologists and other non-systematists. The course focuses on two basic issues: methods and principles for inferring relationships among genes and the use of data to hypothesize relationships among plants. Evolutionary patterns and processes of genes and gene families are discussed, as well as rates of sequence evolution, paralogy and othology, the effects of recombination and concerted evolution of gene phylogenies, and the implications of using gene or allele phylogenies to infer organismal evolutionary patterns. The principles of distance and parsimony methods are described, and computer methods for reconstructing gene phylogenies are discussed.

BIOPL 653 Plant Molecular Biology I
Fall. 1–5 credits (1 credit per section). Prerequisites: BIOGD 281 and BIOBM 330 or 332, or their equivalents. Recommended: BIOBM 331. S-U grades optional.
A series of four-week modules on specialized topics. Coordinator: S. H. Howell.

Section 01 Concepts and Techniques in Plant Molecular Biology (also Plant Breeding 653.1)
1 credit. Lecs, M W F 10:10 (12 lecs) Sept. 4-Sept. 30. J. Steffins, D. B. Stern.
A review and update on molecular biology concepts relevant to plant sciences including DNA synthesis, RNA transcription and processing, and protein structure and translation. Methods applicable to plant molecular biology are described including isolation of nucleic acids, gel electrophoresis, recombinant DNA techniques, mutant production, DNA-protein interactions, and use of antibodies.

Section 02 Plant Biotechnology (also Plant Breeding 653.2 and Plant Pathology 663)
1 credit. Lecs, M W F 10:10 (12 lecs) Sept. 4-Sept. 30. M. Zaitlin, E. D. Earle.
This course deals with production and uses of transgenic plants for agricultural and industrial purposes. Topics include procedures for gene introduction and control of gene expression, as well as strategies for obtaining transgenic plants that are resistant to insects, diseases, and herbicides, produce useful products, or have improved nutritional and food processing characteristics. Regulatory and social issues relating to plant biotechnology are discussed.

Section 03 Plant Genome Organization and Function (also Plant Breeding 653.3)
1 credit. Lecs, M W F 10:10 (12 lecs) Oct. 2-Oct. 30. S. D. Tanksley.
This course covers the origins and measurement of nuclear DNA variation in plants as well as the development and exploitation of molecular markers for breedings and the isolation of genes underlying interesting phenotypes.

Section 04 Molecular Aspects of Plant Development I
1 credit. Lecs, M W F 10:10 (12 lecs) Nov. 4-Dec. 2. J. B. Nasrallah.
This module focuses on the molecular genetics of plant reproduction. Current approaches to the elucidation of the molecular signals and pathways that lead to the establishment of the differentiated state of floral cells and organs are discussed. Topics include the integration of enviornmental and developmental signals during the transition to flowering, the establishment of pattern during floral morphogenesis, cell death and sex determination, gamete development, cell-cell signaling during pollination, and fertilization. The module is a companion to BIOPL 652, Sec 02 (Molecular Aspects of Plant Development II), which covers molecular aspects of vegetative development.

Section 05 Molecular Biology of Plant Organelles
1 credit. S-U grades optional. Lecs, M W F 1:25 (12 lecs) Nov. 4-Dec. 2. M. R. Hanson (odd years), D. B. Stern (even years).
An in-depth examination of the molecular biology of plant mitochondria (odd years) and plastids (even years). Topics include the organization and expression of organelle genomes, RNA editing, organelle transformation, expression of nuclear genes for organelle proteins. Special topics include cytoplasmic male sterility and gene regulation during plastid development.

[BIOPL 654 Botanical Nomenclature
Fall. 1 credit. Prerequisite: written permission of instructor. S-U grades only. Offered alternate years. Not offered 1996–97. Lec and disc to be arranged. Staff.
An analysis of the International Code of Botanical Nomenclature and its application to various plant groups.]

BIOPL 655 Seminar in Ethnobotany
Fall. 2 or 4 credits (4 credits with independent tutorial). Prerequisite: written permission of instructor for undergraduates. Lec, W 1:25; disc, W 2:30. D. M. Bates.
An exploration of ethnobotany, the study of the interrelationships of people and plants viewed from anthropological and botanical perspectives. Contemporary issues, theory, and methodology are considered. Topics include subsistence systems, crop domestication, traditional medicine, indigenous resource management, and preceptions of nature, among others.

BIOPL 656 Topics in Plant Evolution
Spring. 1 credit. Prerequisite: BIOPL 448 or equivalent background in evolution, or written permission of instructor. Lab and disc to be arranged. K. J. Niklas.
A series of selected topics to provide a background in plant evolution, paleobotanical literature, and evolutionary theory. Among the topics discussed are the origin of a terrestrial flora, the evolution of the seed plants, and the origin and adaptive radiation of the angiosperms.

BIOPL 740 Plant Biology Seminar
Fall and spring. No credit (no official registration). Required of graduate students doing work in plant biology. Sem, F 11:15. Staff.
Lectures on current research in plant biology, presented by visitors and staff.

BIOPL 741 Problems in Plant Cell and Molecular Biology
Fall. 2 credits. Limited to first- and second-year graduate students in the Plant Cell and Molecular Biology Program. Disc to be arranged. Staff.
An introduction to the research literature in plant molecular and cellular biology through weekly problem sets and discussions.

BIOPL 742 Current Topics in Plant Molecular Biology
Fall or spring. 1 credit. Enrollment is limited. Primarily for graduate students, with preference given to majors or minors in plant molecular biology; written permission of instructor required for undergraduates. S-U grades only. Sem, 1 hour each week to be arranged. Staff.
A seminar with critical presentation and discussion by students of original research papers concerning the molecular biology of plants. Staff direction varies each year and is announced a semester in advance.

BIOPL 743 Current Research in Plant Cell and Molecular Biology
Fall. 1 credit. Limited to graduate students; written permission from a member of the Plant Cell and Molecular Biology Program required for undergraduates. Lec to be arranged. Staff.
An introduction for graduate students to the research being conducted by Cornell faculty in the Plant Cell and Molecular Biology Program.

BIOPL 749 Graduate Research in Botany
Fall or spring. Variable credit. May be repeated for credit. S-U grades optional. Hours to be arranged. Staff.
Similar to BIO G 499 but intended for graduate students who are working with faculty members on an individual basis.

BIOPL 840 Current Topics in Plant Physiology
Fall or spring. 2 credits. May be repeated for credit. S-U grades only. Sem to be arranged.
Seminar reports by graduate students on current literature in experimental plant physiology or related areas.

Related Courses in Other Departments

Introductory Mycology (Plant Pathology 309)

Marine Botany: Ecology of Marine Plants (Biological Sciences [BIOSM] 449)

Mycology Conferences (Plant Pathology 649)

Phytomycology (Plant Pathology 709)

Plant Ecology and Population Biology, Lectures and Laboratory (Biological Sciences [BIOES] 463 and 465)

Plant Ecology Seminar (Biological Sciences [BIOES] 669)

Plant Cytogenetics Laboratory (Plant Breeding 446)

Teaching Experience (Biological Sciences [BIO G] 498)

Undergraduate Research in Biology (Biological Sciences [BIO G] 499)

COURSES IN MARINE SCIENCE

Cornell offers an extensive listing of undergraduate courses in marine science.

Undergraduates interested in pursuing studies in marine science are encouraged to explore the undergraduate specialization in Marine Biology and Oceanography offered through the Division of Biological Sciences and the summer program of courses offered by the Shoals Marine Laboratory. Further information on both can be found at the Cornell Marine Programs Office, G14 Stimson Hall.

Undergraduate Specialization in Marine Biology and Oceanography

Biological Sciences majors in the ecology and evolutionary biology program of study have the option of specializing their program of study in the areas of marine biology and oceanography. In addition to fulfilling the major and the ecology and evolutionary biology program of study requirements, students in marine biology and oceanography are encouraged to enroll in the following courses:

1) BIOES 154, The Sea: An Introduction to Oceanography,
2) BIOSM 364, Field Marine Science or a 400-level BIOSM field course at the Shoals Marine Laboratory,
3) BIOES 462, Marine Ecology.

Students in this specialization are exposed to an integrated program of study, emphasizing a natural progression of formal course work combined with ample opportunities for practical field experience.

SHOALS MARINE LABORATORY (BIOSM)

G14 Stimson Hall, 255-3717

The objective of the Shoals Marine Laboratory (SML) is to provide undergraduates, beginning graduate students, and other interested adults a unique opportunity to explore marine sciences in an island setting noted for its biota, geology, and history. SML has established a national reputation for excellence and has become North America's largest marine field station focusing on undergraduate education.

The summer population of Appledore Island is limited to about one hundred people at any one time. Participants and faculty members can literally and figuratively immerse themselves in their explorations, free from distractions common to most academic institutions. Because SML is a residential facility, a sense of community develops that makes courses and seminars at SML outstanding educational and intellectual experiences. Participants learn from and exchange ideas with a wide range of specialists whose primary interests are marine but whose perspectives often differ, providing fertile ground for lively discussions.

Credit courses at Shoals Marine Laboratory are full-time, intensive learning experiences. Courses may be taken sequentially, but not concurrently. A typical day combines lecture sessions, laboratory and field work, field trips to nearby islands and the mainland, and collecting and research excursions aboard the Laboratory's 47-foot research vessel, *John M. Kingsbury*. Field experience is an integral component of all courses, using Appledore's extensive intertidal zone, wading bird rookeries, and seabird colonies. Faculty, drawn from Cornell University, the University of New Hampshire, and other leading academic institutions, are selected not only based on their academic excellence, but also on their teaching ability in the field. In addition, numerous guest lecturers include engineers, coastal planners, and specialists from private industry, government, and the academic community.

The Ithaca campus functions of the Shoals Marine Laboratory are centered in the Cornell Marine Programs Office, G14 Stimson Hall. The office serves as an advising center for students interested in the marine sciences, maintains a browsing library with updated information on graduate study and career opportunities as well as on marine programs at other institutions, and administers the SEA Semester, a 17-credit program offered in cooperation with the Sea Education Association (SEA). SML and SEA offer a joint SEA/Island semester for 18 credits, which combines both programs (BIOSM 364, 366, 367, 368, 372).

The following marine sciences courses are currently administered by the Cornell Marine Programs Office.

BIOSM 160 The Oceanography of the Gulf of Maine
Summer. 4 credits. S-U grades optional. Limited to 24 students. A special 2-week course offered aboard the *SSV Corwith Cramer* and at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and an application, contact the SML office, G14 Stimson Hall or the Sea Education Association office at P.O. Box 6, Woods Hole, MA, 02543. Estimated cost (includes tuition, room and board aboard ship and on the island, and ferry transportation), $3,000. Daily lecs, labs, and fieldwork for 2 weeks. SML faculty.
An exciting opportunity to explore the offshore and near-coastal environments of the Gulf of Maine for pre-college and first-year non-science majors. Students spend ten days aboard the Sea Education Association's *SSV Corwith Cramer* and sail from Woods Hole, MA, to the Isles of Shoals via Georges Bank and the Gulf of Maine. Besides operating the ship, students study the many characteristics of this unique ocean environment. Following the sea component, students spend seven days at the Shoals Marine Laboratory to collect data characteristic of the Isles of Shoals coastal environment.

BIOSM 161 Introduction to Field Marine Science
Summer. 4 credits. S-U grades optional. A special 2-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $1,800. Offered alternate years.
This course allows students who are not biology majors to experience the breadth of the marine sciences under field conditions at an island laboratory. Aspects of biology, geology, earth science, chemistry, and physics are included. Specific topics include beach, salt marsh, tidal mud flat, tide pool, and benthic offshore environments; identification of marine plants and animals; chemical and physical oceanography; marine geology; and ecology of kelp beds and urchin barrens.

BIOSM 204 Biological Illustration
Summer. 2 credits. A special 1-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, supplies, and ferry transportation), $950. Daily sessions for 1 week. SML faculty.
General discussion of scientific publishing, illustration labeling, color techniques, and printing processes. The course provides the scientist or science student a chance to experience several illustration techniques with the goal of obtaining an overview of scientific and wildlife illustrations. The student may choose a single technique to explore in depth. Course size is limited so that individual attention can be emphasized.

BIOSM 309 Coastal Ecology and Bioclimates
Summer. 4 credits. Prerequisite: one year of college-level biology; background preferred in physics/physical geography. S-U grades optional. A special 2-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and an application consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $1,850. Daily lecs, labs, and fieldwork for 2 weeks. SML faculty.
A study of the fundamentals of organism-environment interaction developed through defining and measuring abiotic factors including solar radiation, temperature, atmospheric moisture, precipital wind, and currents. On-site exploration of the dynamics of meteorology and the role of abiotic and biotic factors in the life of coastal and marine plants and animals including humans.

BIOSM 327 Neurobiology of Animal Behavior
Summer. 4 credits. Prerequisite: permission of instructor and successful performance in college-level introductory biology and chemistry courses with laboratories. Recommended: course work in neurobiology, psychology, and animal behavior. S-U grades optional. A special 2-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off the coast of Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $1,850. Daily lecs, labs, and fieldwork for 2 weeks. SML faculty.
Neural mechanisms underlie all behaviors, from simple reflexes to complex social interactions. The functional elements of those mechanisms often are common to both vertebrate and invertebrate nervous systems. The course focuses on neural mechanisms of behavior in marine organisms, a topic that has produced significant biomedical discoveries. Students gain hands-on experience with a spectrum of modern research techniques for behavioral, systems, cellular, and molecular approaches. A visiting scientist program allows student interaction with research scientists.

BIOSM 329 Ecology of Animal Behavior
Summer. 4 credits. Prerequisite: one year of introductory college biology. Recommended: course work in ecology, psychology, or behavior. S-U grades optional. A special 2-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $1,850. Daily lecs, labs, and fieldwork for 2 weeks. SML faculty.
The ecological significance of behaviors of coastal organisms, with emphasis on field and laboratory research methods. Lectures and readings address the major subareas of behavior (communication, orientation, social behavior, foraging, predator avoidance, and sensory mechanisms). Each student engages in short-term behavioral observation and prepares a research proposal for studying a problem within the course subject area.

BIOSM 363 Marine Biology for Teachers
Summer. 3 or 4 credits (4-credit option: additional 4 days for individual research). Primarily for teachers, grades 6 through 12, but open to others with teaching experience. Prerequisite: one year of introductory college biology. S-U grades optional. A special 10-day course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $1,850. Daily lecs, labs, and fieldwork for 10 days. SML faculty.
Designed to give an overview of living marine organisms (algae, invertebrates, fishes, marine mammals, and shorebirds) and of the environment they inhabit. Fieldwork is emphasized. Occasional lectures and films deal with additional topics such as coastal-zone problems, marine fisheries, economics of marine organisms, and educational resources of the marine environment.

BIOSM 364 Field Marine Science
Summer. 6 credits. Prerequisite: one year of college biology. S-U grades optional. A special 4-week course offered twice each summer at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML Office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $2,850. Daily lecs, labs, and fieldwork for 4 weeks. 3 core faculty members assisted by up to 15 visiting lecturers, including representatives of governmental agencies. SML faculty.
Designed for the student who desires an initial overview of the marine sciences, this course emphasizes living material in natural habitats. Most of the course work is concerned with the biology of intertidal plants and animals, biological oceanography, ichthyology, and fisheries. Attention is also given to introductory physical and chemical oceanography and marine geology. Marine ecology and the effects of human activity on the marine environment are included. Students apply this knowledge by conducting a transect study toward the end of the course.

BIOSM 365 Underwater Research
Summer. 4 credits. Prerequisites: one year of college-level biology, recognized scuba certification, and a medical examination. S-U grades optional. A special 2-week course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $1,950. Daily lecs and fieldwork for 2 weeks. Team-taught by three faculty members with occasional guest lecturers. Not for recreational divers.
Course covers the philosophy of research, hypothesis testing and experimental design, sampling methods, various underwater techniques, diving physics and physiology, and use of dive tables. Emphasis is on subtidal ecological research. Requirements include critical evaluation of several journal articles and production of a research proposal.

BIOSM 366–370 SEA Semester
In cooperation with the Sea Education Association (SEA), the Shoals Marine Laboratory offers a semester-length sequence of courses designed to provide college undergraduates with a thorough academic, scientific, and practical understanding of the sea. *This sequence is repeated approximately once every two months throughout the year.* Students spend the first half of SEA Semester (a six-week shore component) in Woods Hole, MA, receiving instruction in oceanography, nautical science, and maritime studies. The second half of SEA Semester (a six-week sea component) is spent at sea aboard the R/V *Westward* or the R/V *Corwith Cramer.* Enrollment is open to men and women judged capable of benefiting from SEA Semester; no specific prior training or study is required. Cornell students enrolled in the SEA Semester must take the entire sequence.

For more information, contact the Shoals Marine Laboratory office, G14 Stimson Hall, or call SEA directly at 1-800-552-3633. Program costs are to be paid in place of regular Cornell tuition and fees: tuition for the entire 17-credit SEA Semester, about $8,500; room and board about $2,500.

Instructors for the SEA Semester include faculty of the Sea Education Association and the Woods Hole Oceanographic Institution and others.

Shore Component (six weeks)

BIOSM 366 SEA Introduction to Oceanography
3 credits. Prerequisite: concurrent enrollment in BIOSM 367 and 368. A survey of the characteristics and processes of the global ocean. Oceanographic concepts are introduced and developed from their bases in biology, physics, chemistry, and geology. Provides a broad background in oceanography with special attention to areas pertinent to the subsequent cruise. Guest lecturers from the Woods Hole research community interpret current trends and activities in this rapidly evolving field. Students develop individual projects to be carried out at sea.

BIOSM 367 SEA Introduction to Maritime Studies
3 credits. Prerequisite: concurrent enrollment in BIOSM 366 and 368. An interdisciplinary consideration of our relationship with the marine environment. Covers the elements of maritime history, law, literature, and art necessary to appreciate our marine heritage and to understand the political and economic problems of contemporary maritime affairs.

BIOSM 368 SEA Introduction to Nautical Science
3 credits. Prerequisites: concurrent enrollment in BIOSM 366 and 367. An introduction to the technologies of operation at sea. The concepts of navigation (piloting, celestial, and electronic), naval architecture, ship construction, marine engineering systems, and the physics of sail are taught from their bases in astronomy, mathematics, and physics. Provides the theoretical foundation for the navigation, seamanship, and engineering that students employ at sea.

Sea Component (six weeks)

Courses 369 and 370 take place aboard the R/V *Westward*, a 125-foot steel auxiliary-powered staysail schooner built in 1961, or the R/V *Corwith Cramer*, a 134-foot steel auxiliary-powered brigantine built in 1987 for SEA. Both ships normally put to sea with a ship's company of thirty-four. The professional staff of nine includes the captain, the chief scientist, three science watch officers, three deck watch officers, an engineer, and a steward. In addition, one or more visiting investigators are frequently aboard. Up to twenty-four students round out the complement.

BIOSM 369 SEA Practical Oceanography I

4 credits. Prerequisite: BIOSM 366. Theories and problems raised in the shore component are tested in the practice of oceanography at sea. Students are introduced to the tools and techniques of the practicing oceanographer. During lectures and watch standing, students are instructed in the operation of basic oceanographic equipment; in the methodologies involved in the collection, reduction, and analysis of oceanographic data; and in the attendant operations of a sailing oceanographic research vessel.

BIOSM 370 SEA Practical Oceanography II

4 credits. Prerequisites: BIOSM 368 and 369. Building on the experience of Practical Oceanography I, students assume increasing responsibility for conducting oceanographic research and overseeing operations of the vessel. The individual student is ultimately responsible directly to the chief scientist and the master of the vessel for the safe and orderly conduct of research activities and related operations of the vessel. Each student undertakes an individual research project designed during the shore component.

BIOSM 372 SEA Practical Oceanography III

Summer. 3 credits. Prerequisites: BIOSM 366, 367, and 368. Theories and problems raised in class are tested in the practice of oceanography at sea. During lectures and watch standing, students are instructed in the operation of basic oceanographic equipment, in the methodologies involved in the collection, analysis, and reduction of oceanographic data, and in the attendant operations of sailing an oceanographic research vessel. Group research projects are completed.

BIOSM 402 Marine Pollution

Summer. 4 credits. Prerequisites: one year of college-level biology and chemistry or permission of instructor. S-U grades optional. A special 2-week course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $1,850. Daily lecs, labs, and fieldwork for 2 weeks. SML faculty.

An introduction to marine pollutants; their sources and control/treatment; the effects of marine pollution upon coastal ecosystems; and federal and state water pollution regulatory programs. Laboratory includes training in field collection of water samples, measurement and modeling of effluent plume dispersion, and measurement of microbial indicators of water quality, dissolved nutrients, BOD, dissolved oxygen, and toxicity.

BIOSM 409 Ciliophorology

Summer. 2 credits. Prerequisite: permission of instructor. A special 1-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $950. Daily lecs and lab for 1 week. SML faculty.

A special course that examines ciliophoran biology in depth through lectures and laboratory exercises. Topics include a detailed look at the ciliate faunules found in such diverse habitats as salt marshes, sandy sediment interstitial spaces, the Gulf Stream and the Sargasso Sea, marine caves, and benthic hydrothermal vents. Laboratory focuses on examining silver stained specimens, and covers staining techniques, as well as back scattered and secondary SEM and TEM methodologies.

BIOSM 413 Adaptations of Marine Organisms

Summer. 6 credits. Prerequisite: BIOSM 364 or permission of instructor. S-U grades optional. A special 3-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $2,500. Daily lecs, labs, and fieldwork for 3 weeks. SML faculty.

An introduction to the physiological ecology and functional morphology of marine plants and animals, with emphasis on selected algal and invertebrate examples from the Gulf of Maine. Topics covered include photosynthesis in the marine environment; respiration in intertidal organisms; carbohydrates, proteins, and lipids as nutrients in the sea; acclimation and tolerance of tide-pool biota; and biological responses to competition and grazing. Field and laboratory exercises explore principles and procedures used to characterize the physical, chemical, and biotic environment of intertidal and shallow subtidal organisms, including determination of temperature, light, salinity, oxygen and nutrient levels, and *in vivo* functional analyses of metabolic phenomena. The process of scientific investigation is the predominant theme of the course.

BIOSM 418 Tropical Marine Science

Summer. 8 credits. Limited to 12 students. Prerequisites: one year college-level biology; BioES 261 or BioSM 364 or equivalent; BioSM 365 or equivalent experience; recognized SCUBA certification; medical exam; and permission of instructor. Lec/lab, 2 weeks; 6 weeks monitoring study and individual research projects, including data analysis on computers. D. F. Shapiro.

A special 8-week course offered in Akumal, Mexico. For more details, contact Shoals Marine Laboratory, G-14 Stimson Hall, 255–3717. Estimated cost (includes room, board, tuition, and airfare) $4,000. For competent divers only. In addition to lectures and laboratories covering the basic principles of coral reef ecology, students participate in a coral reef monitoring survey. Following two weeks of course work, students engage in independent research projects. This course applies skills learned in the Underwater Research course at Shoals Marine Laboratory.

BIOSM 449 Marine Botany: Ecology of Marine Plants

Summer. 4 credits. Prerequisite: BIOSM 364 or one year of introductory biology. S-U grades optional. A special 2-week course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $1,850. Daily lecs, labs, and fieldwork for 2 weeks. SML faculty.

An overview of the major marine algal groups, including aspects of anatomy, morphology, development, life histories, physiology, and use. Laboratories and fieldwork emphasize relationships between distribution and major environmental parameters and involve student projects.

BIOSM 477 Marine Vertebrates

Summer. 6 credits. Prerequisites: permission of instructor and a course in vertebrate biology. S-U grades optional. A special 3-week course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $2,500. Daily lecs, labs, and fieldwork for 3 weeks. SML faculty.

Topics in marine vertebrate biology emphasizing laboratory studies, field collections or observations, and readings from the current literature. Topics covered include systematics of fishes of the Gulf of Maine, elasmobranch physiology, interpretation of life history and parameters from otolith microstructure, teleost skeletomuscular structure and function, population biology and the contemporary Gulf of Maine fishery, Mesozoic marine reptiles, the biology of sea turtles in cold water, coloniality in sea birds, avian adaptations to life at sea, evolution and systematics of marine mammals, diving physiology, and ecology and conservation of existing marine mammal populations. Dissection of vertebrate animals is a part of one or more laboratory sessions.

ARKEO Archaeology of Maritime Communities (Archaeology 300: Individual Study in Archaeology)

Summer. 2 credits. Prerequisite: a strong interest in history. A special 1-week course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $950. Daily lecs, labs, and fieldwork for 1 week. SML faculty.

Fieldwork on various land sites and their adjacent offshore marine environments. Artifact analysis, preliminary conservation, and the proper recording of finds are emphasized. Methods of archaeological research, including the use of archives and historical materials, and publication methodologies as well as the larger questions in the discipline are discussed.

ARKEO Archaeology Underwater (Archaeology 319)

Summer. 2 credits. Prerequisites: recognized scuba certification and a medical examination required for students engaging in underwater research; also open to non-divers. A special 1-week course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $950. Daily lecs, labs, and fieldwork for 1 week. SML faculty.

An introduction to the subject and a review of this contemporary subdiscipline of archaeology. The approach of the course is practical, with a strong potential for actual on-site experience in search, site recognition, survey, and recording. The course also covers the history and development of the subject, the legal aspects of underwater research, and the worldwide potential of the field. Since any archaeological research project involves a great deal more than digging, the course provides ample opportunities for those who are interested in the subject but are not divers or sufficiently experienced in scuba.

GEOL Marine and Coastal Geology (Geological Sciences 213)

Summer. 2 credits. Prerequisite: an introductory course in geology or permission of instructor. A special 1-week course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $950. Daily lecs, labs, and fieldwork for 1 week. SML faculty.

With "the New England coast" defined as beginning at the -200 meter isobath and proceeding westward, this course examines specific geological events and processes important in shaping the area's bedrock and surficial sediments. Petrology, geophysics, and the Pleistocene geology of the region are investigated. Consideration of the geologic history of New England within the plate tectonic model is emphasized. Examination of insular geology is used to integrate micro-, meso-, and macro-scale geological evolution of continental margins in general. Marine geology is approached through basic geophysical exploration and bottom-sediment collection followed by data analysis and interpretation. Experience aboard a coastal research vessel is an integral part of the course.

NTRES Coastal and Oceanic Law and Policy (Natural Resources 306)

Summer. 2 credits. A special 1-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $950. Daily lecs and disc for 1 week. SML faculty.

Intended for persons interested in careers in management of marine or coastal resources or in the natural sciences. Subjects include law and policy related to ocean dumping, marine sanctuaries, environmental impact statements, water and air pollution, fisheries management, offshore gas and oil production, and territorial jurisdiction. Lectures on the status and history of law are accompanied by discussion of relevant policy and analysis of the efficacy of various legal techniques. A case study that requires extensive use of the laboratory's library and personnel is assigned. The week concludes with a mock hearing.

NTRES Wetland Resources (Natural Resources 417)

Summer. 2 credits. Prerequisite: one year of college-level biology. A special 1-week course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $950. Daily lecs, labs, and fieldwork. SML faculty.

An examination of coastal and adjacent freshwater wetlands from historic, destruction, and preservation perspectives, including fresh- and salt-marsh ecology and management. Field trips to selected examples of the wetlands under discussion and follow-up laboratories emphasize successional features, plant identification and classification, and examination of the dominant insect and vertebrate associations.

FACULTY ROSTER

New York State College of Agriculture and Life Sciences

Adler, Kraig K., Ph.D., U. of Michigan. Prof., Neurobiology and Behavior

Alani, Eric E., Ph.D., Harvard U. Asst. Prof., Genetics and Development

Anderson, John M., Ph.D., New York U. Prof. Emeritus, Genetics and Development

Banks, Harlan P., Ph.D., Cornell U. Liberty Hyde Bailey Prof. of Botany Emeritus, Plant Biology

Bates, David M., Ph.D., U. of California at Los Angeles. Prof., Bailey Hortorium

Beyenbach, Klaus W., Ph.D., Washington State U. Prof., Physiology/Veterinary Physiology†

Bruns, Peter J., Ph.D., U. of Illinois. Prof., Genetics and Development

Cade, Thomas J., Ph.D., U. of California at Los Angeles. Prof. Emeritus, Ecology and Systematics

Calvo, Joseph M., Ph.D., Washington State U. William T. Keeton Professor in Biological Sciences, Biochemistry, Molecular and Cell Biology

Chabot, Brian F., Ph.D., Duke U. Prof., Ecology and Systematics

Clayton, Roderick K., Ph.D., California Inst. of Technology. Prof. Emeritus, Plant Biology

Corradino, Robert A., Ph.D., Cornell U. Prof., Physiology/Veterinary Physiology

Crepet, William L., Ph.D., Yale U. Prof., Bailey Hortorium*

Daniel, Louise J., Ph.D., Cornell U. Prof. Emeritus, Biochemistry, Molecular and Cell Biology

Davies, Peter J., Ph.D., U. of Reading (England). Prof., Plant Biology*

Davis, Jerrold I., Ph.D., U. of Washington. Assoc. Prof., Bailey Hortorium

Dhondt, André A., Ph.D., Ghent State U. (Belgium). Edwin H. Morgens Professor of Ornithology, Ecology and Systematics/ Laboratory of Ornithology

Dondero, Norman C., Ph.D., Cornell U. Prof. Emeritus, Microbiology

Doyle, Jeffrey J., Ph.D., Indiana U. Assoc. Prof., Bailey Hortorium

Dress, William J., Ph.D., Cornell U. Prof. Emeritus, Bailey Hortorium

Ealick, Steven E., Ph.D., U. of Oklahoma. Prof., Biochemistry, Molecular and Cell Biology

Eisner, Thomas, Ph.D., Harvard U. Jacob Gould Schurman Professor, Neurobiology and Behavior

Emlen, Stephen T., Ph.D., U. of Michigan. Jacob Gould Schurman Professor, Neurobiology and Behavior

Feeny, Paul P., Ph.D., Oxford U. (England). Prof., Ecology and Systematics/Entomology

Fitzpatrick, John W., Ph.D., Princeton U. Prof., Ecology and Systematics/Laboratory of Ornithology

Flecker, Alexander, S., Ph.D., U. of Maryland. Asst. Prof., Ecology and Systematics

Fox, Thomas D., Ph.D., Harvard U. Prof., Genetics and Development

Ghiorse, William C., Ph.D. Rensselaer Polytechnic Inst. Prof., Microbiology

Gibson, Jane, Ph.D., U. of London (England). Prof., Biochemistry, Molecular and Cell Biology

Goldberg, Michael L., Ph.D., Stanford U. Assoc. Prof., Genetics and Development

Hanson, Maureen R., Ph.D., Harvard U. Prof., Genetics and Development

Harrison, Richard G., Ph.D., Cornell U. Prof., Ecology and Systematics

Harris-Warrick, Ronald M., Ph.D., Stanford U. Prof., Neurobiology and Behavior

Harvell, C. Drew, Ph.D., U. of Washington. Assoc. Prof., Ecology and Systematics

Helmann, John D., Ph.D., U. of California at Berkeley. Assoc. Prof., Microbiology

Hopkins, Carl D., Ph.D., Rockefeller U. Prof., Neurobiology and Behavior

Howarth, Robert W., Ph.D., Massachusetts Inst. of Technology/Woods Hole Oceanographic Institution. David R. Atkinson Professor in Ecology and Environmental Biology, Ecology and Systematics/Soil, Crop, and Atmospheric Sciences

Ingram, John W., Ph.D., U. of California at Berkeley. Prof. Emeritus, Bailey Hortorium

Jagendorf, André T., Ph.D., Yale U. Liberty Hyde Bailey Professor of Plant Physiology, Plant Biology

Keller, Elizabeth B., Ph.D., Cornell U. Prof. Emeritus, Biochemistry, Molecular and Cell Biology

Kemphues, Kenneth J., Ph.D., Indiana U. Assoc. Prof., Genetics and Development

Kingsbury, John M., Ph.D., Harvard U. Prof. Emeritus, Plant Biology

Lis, John T., Ph.D., Brandeis U. Prof., Biochemistry, Molecular and Cell Biology*

Loew, Ellis R., Ph.D., U. of California at Los Angeles. Assoc. Prof., Physiology/ Veterinary Physiology†

Luckow, Melissa A., Ph.D., U. of Texas at Austin. Asst. Prof., Bailey Hortorium

MacDonald, Russell E., Ph.D., U. of Michigan. Prof. Emeritus, Biochemistry, Molecular and Cell Biology

MacIntyre, Ross J., Ph.D., Johns Hopkins U. Prof., Genetics and Development

Madsen, Eugene L., Ph.D., Cornell U. Asst. Prof., Microbiology

Marks, Peter L., Ph.D., Yale U. Prof., Ecology and Systematics

McCune, Amy R., Ph.D., Yale U. Assoc. Prof., Ecology and Systematics

Mortlock, Robert P., Ph.D., U. of Illinois. Prof., Microbiology

Nasrallah, June B., Ph.D., Cornell U. Assoc. Prof., Plant Biology
Nasrallah, Mikhail E., Ph.D., Cornell U. Prof., Plant Biology
Naylor, Harry B., Ph.D., Cornell U. Prof. Emeritus, Microbiology
Niklas, Karl J., Ph.D., U. of Illinois. Prof., Plant Biology
Nixon, Kevin C., Ph.D., U. of Texas at Austin. Assoc. Prof., Bailey Hortorium
Owens, Thomas G., Ph.D., Cornell U. Assoc. Prof., Plant Biology
Paolillo, Dominick J., Jr., Ph.D., U. of California at Davis. Prof., Plant Biology
Parthasarathy, Mandayam V., Ph.D., Cornell U. Prof., Plant Biology
Quaroni, Andrea, Ph.D., U. of Pavia (Italy). Prof., Physiology
Reeve, H. Kern, Ph.D., Cornell U. Asst. Prof., Neurobiology and Behavior
Roberts, Jeffrey W., Ph.D., Harvard U. Robert J. Appel Professor of Cellular and Molecular Biology, Biochemistry, Molecular and Cell Biology
Rodriguez, Eloy, Ph.D., U. of Texas. Prof., Bailey Hortorium/Plant Biology
Root, Richard B., Ph.D., U. of California at Berkeley. Prof., Ecology and Systematics/Entomology
Russell, James B., Ph.D., U. of California at Davis. Prof., Microbiology
Seeley, Jr., Harry W., Ph.D., Cornell U. Prof. Emeritus, Microbiology
Shalloway, David I., Ph.D., Massachusetts Inst. of Technology. Greater Philadelphia Prof., Biochemistry, Molecular and Cell Biology
Shapleigh, James P., Ph.D., U. of Georgia. Asst. Prof., Microbiology
Spanswick, Roger M., Ph.D., U. of Edinburgh (Scotland). Prof., Plant Biology
Srb, Adrian M., Ph.D., Stanford U. Jacob Gould Schurman Prof. Emeritus, Genetics and Development
Steward, Frederick C., Ph.D., U. of Leeds (England). Charles A. Alexander Prof. Emeritus, Biological Sciences
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Tye, Bik-Kwoon, Ph.D., Massachusetts Inst. of Technology. Prof., Biochemistry, Molecular and Cell Biology
Uhl, Charles H., Ph.D., Cornell U. Prof. Emeritus, Plant Biology
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Vogt, Volker M., Ph.D., Harvard U. Prof., Biochemistry, Molecular and Cell Biology
Walcott, Charles, Ph.D., Cornell U. Prof., Neurobiology and Behavior/Laboratory of Ornithology
Wayne, Randy O., Ph.D., U. of Massachusetts. Assoc. Prof., Plant Biology
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Wu, Ray, Ph.D., U. of Pennsylvania. Prof., Biochemistry, Molecular and Cell Biology
Zahler, Stanley A., Ph.D., U. of Chicago. Prof. Emeritus, Genetics and Development
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Other Teaching Personnel

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Calvo, Rita A., Ph.D., Cornell U. Sr. Lecturer, Genetics and Development
Cordts, Marcia L., Ph.D., Cornell U. Lecturer, Microbiology
Ecklund, P. Richard, Ph.D., Oregon State U. Sr. Lecturer, Neurobiology and Behavior
Glase, Jon C., Ph.D., Cornell U. Sr. Lecturer, Neurobiology and Behavior
Heiser, John B., Ph.D., Cornell U. Sr. Lecturer, Ecology and Systematics
McFadden, Carol H., Ph.D., Cornell U. Sr. Lecturer, Physiology
Merkel, Susan, M.S., Cornell U. Lecturer, Microbiology
Nivison, Helen T., Ph.D., U. of California at Davis. Lecturer, Biochemistry, Molecular and Cell Biology
Rehkugler, Carole M., M.S., Cornell U. Sr. Lecturer, Microbiology
Reiss, H. Carol, M.S., Cornell U. Sr. Lecturer, Plant Biology
Sneath, Barbara, Ph.D., Syracuse U. Lecturer, Genetics and Development
Tyler, Bonnie M., Ph.D., Massachusetts Inst. of Technology. Lecturer, Biochemistry, Molecular and Cell Biology

Joint Appointees

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Borror, Arthur C., Adjunct Prof., U. of New Hampshire/Biological Sciences
Foote, Robert H., Jacob Gould Schurman Prof. Emeritus, Animal Science/Physiology
Greene, Charles H., Adjunct Assoc. Prof., Geological Sciences/Ecology and Systematics
Howell, Stephen H., Adjunct Prof., Boyce Thompson Institute/Plant Biology
Kochian, Leon V., Adjunct Assoc. Prof., USDA Science and Education Administration/Plant Biology
Korf, Richard P., Prof. Emeritus, Plant Pathology/Bailey Hortorium
LaRue, Thomas A., Adjunct Prof., Boyce Thompson Institute/Plant Biology
Last, Robert L., Adjunct Assoc. Prof., Boyce Thompson Institute/Genetics and Development
Liebherr, James K., Assoc. Prof., Entomology/Bailey Hortorium
Pimentel, David, Prof., Entomology/Ecology and Systematics
Richmond, Milo E., Assoc. Prof., USDI Fish and Wildlife Service/Natural Resources/Ecology and Systematics
Rossman, Michael J., Adjunct Prof., Purdue U./Biochemistry, Molecular and Cell Biology
Stern, David B., Adjunct Assoc. Prof., Boyce Thompson Institute/Plant Biology
Thompson, John F., Adjunct Prof., USDA Science and Education Administration/Plant Biology
Via, Sara, Assoc. Prof., Entomology/Ecology and Systematics
Weeden, Norman F., Assoc. Prof., Horticultural Sciences/Bailey Hortorium
Wheeler, Quentin D., Assoc. Prof., Entomology/Bailey Hortorium

College of Arts and Sciences

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Deitcher, David, Ph.D., Howard Med. School. Asst. Prof., Neurobiology and Behavior
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Geber, Monica A., Ph.D., U. of Utah. Asst. Prof., Ecology and Systematics
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Gilbert, Perry W., Ph.D., Cornell U. Prof. Emeritus, Neurobiology and Behavior
Hairston, Nelson G., Jr., Ph.D., U. of Washington. Prof., Ecology and Systematics
Halpern, Bruce P., Ph.D., Brown U. Prof., Neurobiology and Behavior/Psychology
Hedin, Lars O., Ph.D., Yale U. Asst. Prof., Ecology and Systematics
Heppel, Leon A., Ph.D., U. of California at Berkeley. Prof. Emeritus, Biochemistry, Molecular and Cell Biology
Hess, George P., Ph.D., U. of California at Berkeley. Prof., Biochemistry, Molecular and Cell Biology
Hinkle, Peter C., Ph.D., New York U. Prof., Biochemistry, Molecular and Cell Biology
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Podleski, Thomas R., Ph.D., Columbia U. Prof., Neurobiology and Behavior‡
Power, Alison G., Ph.D., U. of Washington. Assoc. Prof., Ecology and Systematics/Science and Technology Studies
Provine, William B., Ph.D., U. of Chicago. Charles A. Alexander Professor of Biological Sciences, Ecology and Systematics/History
Salpeter, Miriam M., Ph.D., Cornell U. Prof., Neurobiology and Behavior/Applied and Engineering Physics§

Schneiderman, Anne M., Ph.D., Harvard U. Asst. Prof., Neurobiology and Behavior
Seeley, Thomas D., Ph.D., Harvard U. Prof., Neurobiology and Behavior
Sherman, Paul W., Ph.D., U. of Michigan. Prof., Neurobiology and Behavior
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Wilson, David B., Ph.D., Stanford U. Prof., Biochemistry, Molecular and Cell Biology
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Johnson, Bruce R., Ph.D., Boston U. Sr. Lecturer, Neurobiology and Behavior

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Tapper, Daniel N., Ph.D., Cornell U. Prof., Physiology/Veterinary Physiology
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Other Teaching Personnel

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Joint Appointees

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Houpt, T. Richard, Prof., Veterinary Physiology/Physiology
Nathanielsz, Peter W., Leading Prof., Clinical Sciences/Veterinary Physiology/Physiology
Wootton, John F., Prof., Veterinary Physiology/Physiology

College of Engineering

Joint Appointees

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Jelinski, Lynn W. Prof., Biotechnology Program/Biological Sciences
Webb, Watt W., Prof., Applied and Engineering Physics/Biological Sciences

Division of Biological Sciences

Stinson, Harry T., Jr., Ph.D., Indiana U. Prof., Biological Sciences/Genetics and Development*

Division of Nutritional Sciences

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§Joint appointment with the College of Engineering.